

Microsurgical Management of Middle Ear and Petrous Bone Cholesteatoma

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- Video 14.1** Transotic approach for a petrous bone cholesteatoma.
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Preface

This is our third book dealing with microsurgery of cholesteatoma. Former two books, *Middle Ear Microsurgery* first and second editions, were focused on full range of middle ear surgeries, and surgery for cholesteatoma comprises only a part of them. Since cholesteatoma surgery is considered to be one of the most difficult otologic surgeries with many techniques to be described, we think former two books are not sufficient to fully note down our experiences. Therefore, we decided to dedicate our next work to only this pathology.

Regarding middle ear cholesteatoma, therapeutic strategy ranges from conservative follow-up to surgical eradication. But all otolaryngologists need to keep in mind that the only real therapy for cholesteatoma is surgery, and inattentive conservative management may decrease possibility of curing patients without consequences. Possible exception is elderly with very bad health condition, but even in such patients, surgery can be performed under local anesthesia if the surgeon is confident of carrying out all procedures within 2 hours. We believe that the surgeon must have, at least, an ability of local anesthesia in his arsenal.

In this book, we have tried to provide the complete range of information which is required to cure the pathology. Clinical diagnosis is made under otoscopy in the majority of cases, and radiologic diagnosis is indispensable to evaluate its extension. In limited cases, only neurologic deficit is a clue of diagnosis, and high grade of suspicion followed by careful radiologic examination is required. Different procedures have been described in each chapter. The traditional surgical procedures include retroauricular transcanal approach, canal wall up and down tympanoplasty with either one stage or two stages, radical and conservative mastoidectomy, and modified Bondy technique. Through our clinical experience of more than 30 years, these procedures are proved to be very effective if therapeutic algorithm is appropriately adapted to the pathology. Many surgeons stick to single procedure such as canal wall up or down, but we think this is not reasonable. Since status of the pathology and pathogenesis are different in each patient, treatment should be different. Not only extension of disease, but many other factors also need to be considered such as age, cochlear and vestibular function, function of the eustachian tube, and contralateral hearing. Therefore, even though cholesteatoma is a surgical disease, therapeutic strategy remains of primary importance. We strongly believe that the technique should be adapted to the patient rather than have the patient adapt to a technique. Self-descriptive surgical pictures arranged in step-by-step manner will help readers understand our strategy.

We have included a special chapter to cover our new treatment, subtotal petrosectomy. The technique includes blind-sac closure of the external auditory canal and removal of all pathology in the middle ear with the bone around. The cavity is packed with abdominal fat, but the inner ear function is spared. Before adopting this technique, patients are usually operated many times but the condition seems resistant to any kind of therapy, leading to finally declaring the condition as inoperable. Such patients are forced to keep away from any kind of water sports and they always have to be careful to avoid water entering the cavity. After subtotal petrosectomy, however, they can live a normal life and they can practice water sports without any harmful consequences. The only problem for these patients is a need of follow-up with MRI, with diffusion-weighted modality to detect minimal

residual cholesteatoma in the obliterated cavity. If small residue is detected, its removal is usually an easy procedure that can be performed via retroauricular incision under local anesthesia. A chapter for our other new treatment, cochlear implant in cholesteatoma surgery, has been included. In rare cases, cholesteatoma heavily erodes the inner ear on both sides, or the inner ear in the only hearing ear. Thanks to current advanced technology, we have a possibility to save hearing if the implant is inserted during surgery. This technique should be known to otoneurosurgeons.

Another new chapter describes petrous bone cholesteatoma, which is less frequent but much more difficult to diagnose and to treat. There are so far other terms such as petrous apex cholesteatoma to describe this entity. However, in our opinion, petrous bone cholesteatoma is the right nomenclature, because the disease can involve the entire, and not just a part of, petrous bone. The term petrous bone cholesteatoma is the right name to be used in publications. This chapter is of particular importance, because as far as we know, there is no book describing all the treatments of removal of this very invasive pathology.

Petrous bone cholesteatoma is, namely, the pathology of lateral skull base. The pathology requires much more diagnostic work-up than the middle ear cholesteatomas, because it needs high-resolution CT scan, MRI T1 and T2 with gadolinium enhancement, and sometimes angio-MRI in order to know the function of veins, and relationship between cholesteatoma and the carotid artery. The surgery needs to deal with vital structures, the middle and the posterior fossa dura, the sigmoid sinus, the jugular bulb, the carotid artery, and sometimes, the jugular vein in the neck. In more extended cases, we have to treat extension to the sphenoid sinus and intradural space. Surgeons need to know all the techniques and cranio-temporal-cervical anatomy, and need to have experience as otologist, neurotologist, otoneurosurgeon, and head and neck surgeon. In order to adapt the technique to the patient, not vice versa, we have adopted and modified the Fisch classification based on our experience. According to our classification, appropriate surgical approach can be chosen. The chapter is particularly enhanced by beautiful computer drawings made by Dr. Mancini. With these drawings and X-rays, readers can understand three-dimensional relationship between pathology and vital structures and figure out necessity of the approach chosen in the surgery.

Special thanks go to Professor Hiroshi Sunose, Head of Department of Medical Center East, Tokyo Women's Medical University. He did practically all the work to finish this book. Without his contribution, we at Gruppo Otologico could not have finished this wonderful book, the same as previous two middle ear books. I also thank Dr. Fernando Mancini for making all the wonderful drawings. We had continuous exchange of ideas for drawings in the operating room before we got the best ones. I also thank Dr. Taibah and Dr. Russo for operating patients and curing them. All coauthors helped a lot in our clinical work. I would like to express special thanks to my great teachers: Carlo Zini, Jim Sheehy, and William House. I would also like to acknowledge Stephan Konnry at Thieme Publishers for his great help.

Mario Sanna, MD

Time passes so quickly. Seventeen years ago, I was wondering if I could be a good doctor when I knocked the door of Gruppo Otológico with very little idea about middle ear and lateral skull base surgeries. Fortunately, I was lucky enough to knock the right door as I met a great teacher, Professor Sanna, in a great school. Professor Sanna not only taught me surgery, but also told me these precious words: "Nothing is easy in middle ear surgery," and "The best way to learn is to teach." The 17 years did not erode the significance of these words at all, but rather the words become more and more meaningful as time passed by. I have been learning a

lot through writing books and keep revising my surgical strategy and technique continuously. What amazes me about Professor Sanna is that there is always something new to learn from him. Nothing is easy in middle ear surgery.

I would feel so happy if I can help patients all over the world by writing this book, by imparting knowledge, and by improving surgical skills of all readers.

Hiroshi Sunose, MD

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1 Anatomy and Radiology of the Normal Temporal Bone

Basic anatomical knowledge of important structures that may be encountered during middle ear surgery is described here. Since three-dimensional anatomy of the middle ear is so complicated, it is impossible to figure out its entity only through these flat pictures. Intensive work in temporal bone dissection laboratory is mandatory. More detailed anatomy of deep structures in the temporal bone is described in Chapter 14.

1.1 The External Auditory Canal

The osseous portion accounts for medial one-third of the external auditory canal. The skin lying on the bony canal is extremely thin, only 0.2 mm in thickness, and requires meticulous care during dissection. Two sutures between elemental structures forming the temporal bone appear in the canal. The tympanosquamous suture is located anterosuperiorly and the tympanomastoid suture posteroinferiorly. Connective tissue enters into these suture lines and sharp dissection may be required during meatal skin elevation. The glenoid fossa, which receives mandibular condyle to form the temporomandibular joint, is located just anterior to the canal, and separated from the canal only by thin bony shell.

1.2 The Tympanic Membrane

The conically shaped tympanic membrane is tilted anteroinferiorly. Because of this dimension, the anteroinferior bony wall is longer than the posterosuperior one, and the anterior tympanomeatal angle is more acute than the posterior. The anterior angle is often hindered by a bony protrusion of the anterior wall. Sufficient visualization of this angle is the key for successful tympanic membrane reconstruction. The tympanic membrane is composed of three layers. Laterally, it is covered with an epidermal layer, and medially with a mucosal layer. Between these two layers, a fibrous layer, the lamina propria exists. The lamina propria may be lost in an atrophic tympanic membrane, and may be thickened by a tympanosclerotic plaque. The tympanic membrane is divided into two parts. The pars tensa, located inferiorly to the lateral process of the malleus and the anterior and the posterior malleal folds, occupies majority of the tympanic membrane. The lamina propria thickens in the periphery of the pars tensa to form tympanic annulus. The tympanic annulus is attached to a groove on the bony canal called the tympanic sulcus. The pars flaccida is located superiorly to the lateral process of the malleus, and delineated superiorly by a bony notch in the superior canal wall called the Rivinus notch. Medial to the pars flaccida and lateral to the neck of the malleus is the Prussak's space, where epitympanic cholesteatoma starts to invaginate medially from the pars flaccida.

1.3 The Ossicular Chain

1.3.1 The Malleus

The manubrium of the malleus is firmly attached to the tympanic membrane. Its tip corresponds to the umbo of the tympanic

membrane which is the bottom of its conical shape. The lateral process is located at the superolateral end of the manubrium. Because of its proximity to the superolateral canal wall, meticulous care should be taken not to touch this process with burrs during canalplasty. The head of the malleus is located in the attic, and its neck connects the head and the manubrium. The tendon of the tensor tympani muscle attaches to the medial surface of the neck. Contraction of the muscle pulls the ossicle medially, and resultant tension to the tympanic membrane limits sound transmission to the inner ear to some extent. The head of the malleus is supported by the superior suspensory ligament and the anterior suspensory ligament.

1.3.2 The Incus

The body of the incus forms an articulation anteriorly with the head of the malleus. The short process of the incus projects posteriorly. The short process is lodged in the fossa incudis located just anterior to the eminence of the lateral semicircular canal (LSC). It is important to know. The long process projects into the tympanic cavity, and forms an articulation with the stapes at its lenticular process. The incus is supported by the malleus anteriorly and the posterior incudal ligament posteriorly.

1.3.3 The Stapes

The smallest bone in the human body is located in the oval window. The stapes sits in a deep depression called oval window niche as described in subsequent text. The head of the stapes forms an articulation with the incus. The stapedius muscle inserts onto the head and the posterior crus. The footplate is accommodated in the oval window that is an opening of the vestibule and the scala vestibuli of the cochlea. The connective tissue lying between the footplate and the edge of the oval window is called the annular ligament. A contraction of the stapedius muscle tilts the stapes and its footplate, and resulting tension in the annular ligament limits sound transmission into the inner ear to some extent.

1.4 The Tympanic Cavity

Mesotympanum is a portion located just medial to the tympanic membrane. It is bordered superiorly from the epitympanum (attic) by the tympanic segment of the facial nerve. A recess inferior to the tympanic membrane is the hypotympanum. The protympanum, located anteriorly to the tympanic membrane, has the tympanic orifice of the eustachian tube, just inferior to the semicanal of the tensor tympani muscle. A branch of the facial nerve, the chorda tympani, courses lateral to the long process of the incus and medially to the manubrium of the malleus after emerging from the posterior wall. The nerve contains sensory fibers for taste and secretory fibers innervating the submandibular and sublingual glands.

1.4.1 Medial Wall

The Facial Nerve

The tympanic segment of the facial nerve courses obliquely in the medial wall of the tympanic cavity from the area just superior to the eustachian tube, toward the area just superior to the oval window. Since the nerve is dehiscant in this segment in about one-third of the cases, meticulous care should be taken during operation. Above the oval window, the nerve forms a prominence that may be large enough to cover the area of the footplate. Around the posterior edge of the oval window, the nerve follows gentle curve directing inferolaterally, changing its location from the medial wall to the posterior wall. At that turning portion, the nerve is positioned inferomedially to the LSC, and courses almost parallel to it. The short process of the incus lies just laterally to the nerve (see also Chapter 1.8).

The Cochleariform Process

The cochleariform process lodges posterior end of the semicanal of tensor tympani. It is located just medial to the neck of the malleus, anterosuperior to the oval window, and just inferolateral to the tympanic segment of the facial nerve. At this bony process, tendon of the tensor tympani muscle makes a right angle and directs laterally to attach to the neck of the malleus.

The Promontory

The promontory is a prominent eminence located anteroinferiorly to the oval window, and anteriorly to the round window. It corresponds to the basal turn of the cochlea. The axis of the cochlea directs anteriorly and laterally.

The Oval Window

The stapes footplate is lodged in this window to transmit the mechanical energy to the scala vestibuli of the cochlea. The window is located at the bottom of a deep depression surrounded by eminences, the promontory inferiorly, the fallopian canal superiorly, the cochleariform process anteriorly, and the pyramidal eminence posteriorly. The window edge and the stapes footplate are connected by the connective tissue called the annular ligament. The tympanic segment of the facial nerve runs just superior to the window, and near the posterior edge of it, the nerve turns inferiorly toward the stylomastoid foramen.

The Round Window

The round window is located in the round window niche, inferiorly to the oval window. The round window is the other opening of the labyrinth to the middle ear. With this window, the cochlear fluid contained in bony structure is vulnerable to mechanical vibration. The round window membrane lodges superior aspect of the round window niche, and lies mostly in the horizontal plane.

Therefore, it is difficult to see directly the membrane without removing superior overhang of the niche.

1.4.2 Posterior Wall

The posterior tympanum contains deep recesses. The facial nerve running in the middle divides them into the tympanic sinus medially and the facial recess laterally. These recesses are subdivided by two bony eminences that join the pyramidal eminence on the facial nerve. The eminence contains the stapedius muscle that attaches to the head of the stapes.

The Tympanic Sinus

The sinus is located medially to the facial nerve. The posterior extension of the sinus tympani is variable, and it may extend far medially to the facial nerve. Since direct visualization of its bottom is impossible in the majority of cases, eradication of the disease from this sinus requires considerable experience. The tympanic sinus is subdivided into two segments located superiorly and inferiorly, by a bony bridge named the ponticulus that connects pyramidal eminence and the promontory. The tympanic sinus is bordered inferiorly by another bony bridge lying between the posterior wall and the round window niche, called the subiculum.

The Facial Recess

The facial recess is bordered by the bony annulus laterally and the facial canal medially. This is the portion to be drilled for posterior tympanotomy in canal wall up tympanoplasty. The facial recess is also subdivided into two segments by a bony bridge called the chordal crest that connects the pyramidal eminence and an emergence of the chorda tympani called the chordal eminence. The inferior extension of the facial recess is variable, depending on the point of exit of the chorda tympani from the facial nerve.

1.4.3 The Attic

A bony spur called the cog extends vertically from the tegmen to a point just anterior to the head of the malleus. With this structure, the attic is divided into a posterior division and an anterior division known as the supratubal recess. Cholesteatoma often advances into the recess, and the recess often becomes a site of residual if it is not opened fully during surgery. Since the cog is located superiorly to the facial nerve with its tip pointing it, the structure serves as one of the landmarks of the nerve. The floor of the anterior attic recess contains the pregeniculate portion of the facial nerve. Posterior to the attic, an opening of the antrum called aditus ad antrum is located.

1.4.4 The Antrum

The antrum connects the mastoid air cells with the tympanic cavity. It is located just posteriorly to the epitympanum, inferiorly to the middle fossa plate, and laterally to the labyrinth.

Since the antrum is very consistent and there is no important structure lateral to it, the antrum serves as one of the most important landmarks in the initial stage of mastoidectomy. The prominence of the LSC is one of the most important landmark for the facial nerve.

1.5 The Labyrinth

The prominence of the LSC in the medial wall of the antrum is sloping about 30 degrees, running from anterosuperior to posteroinferior. The bony capsule of the labyrinth is compact and hard, and more resistant to bone erosion. However, due to its proximity to the antrum, the LSC is the most vulnerable labyrinth to pathologies that erodes the medial wall of the antrum such as cholesteatoma. At the anterior end of the LSC is the ampulla that accommodates sensory cells and opens to the utricles. The ampulla is located in the medial wall of the posterior attic.

Other two semicircular canals are sited nearly perpendicularly to the LSC. The posterior semicircular canal (PSC) lies just posterior to the LSC, and the posterior edge of the LSC points almost the center of the PSC. The PSC courses nearly in parallel with the posterior fossa dura. Its ampulla is located at its inferior end, just medial to the facial nerve. The superior end of the PSC joins the superior semicircular canal (SSC), forming the common crus.

The SSC is located just beneath the middle cranial fossa plate. Its ampulla is at the anterior end, just superomedial to the ampulla of the LSC. It courses nearly perpendicular to the long axis of the pyramis, which places the canal deeper and farther from the antrum posteriorly. Therefore, the canal is not seen in the majority of cases, and the entire canal may be exposed in limited cases in which intensive removal of perilyabyrinthine cells are required such as petrous bone cholesteatoma. In rare cases, the canal is dehiscence and directly contacts with the middle fossa dura.

The ampullae of the superior and the LSCs are located in the medial wall of the posterior attic. The anterior walls of the two ampullae become parallel to the light axis of the microscope medially when seen from the posterior cavity. Therefore, if there is any necessity to drill deeply the medial wall of the attic, great care should be taken not to open these two ampullae. The labyrinth is less resistant to an insult of the ampulla than that of semicircular canals.

1.6 The Jugular Bulb

The structure is located in the foramen jugulare, connecting the lateral sinus and the internal jugular vein. The jugular bulb is located medial to the mastoid segment of the facial nerve, and inferior to the semicircular canals. Distance from the facial nerve and the labyrinth varies, and the bulb is variably positioned in the hypotympanum. In some cases, the bulb in the hypotympanum is dehiscence. It should be remembered that the lower cranial nerves from 9th to 11th pass the skull base with this venous system.

1.7 The Carotid Artery

The carotid artery enters the temporal bone through the carotid foramen. It ascends vertically and emerges in the medial wall of the hypotympanum at the area just beneath the cochlea. Then, it turns anteromedially with nearly a right angle toward the petrous apex, forming horizontal segment just posteroinferior to the eustachian tube, and anteroinferior to the cochlea. In 2% of cases, a bony shell separating the carotid artery and the eustachian tube is absent. Distance between the cochlea and the carotid artery ranges from 1 to 5 mm.

1.8 The Facial Nerve

Total length of the facial nerve in the temporal bone is around 30 mm. Within the temporal bone, the nerve is divided into three segments. The labyrinthine segment runs laterally from the fundus of the internal auditory canal until it reaches to the geniculate ganglion that lodges cell bodies of sensory somatic nerves serving for taste. The ganglion is located immediately superior to the cochlea, beneath the middle fossa plate. As described, the ganglion may have direct contact with the middle fossa dura in the anterosuperior aspect without any bony shell in between. At the geniculate ganglion, the nerve turns abruptly posteriorly. The tympanic segment starts from the geniculate ganglion, coursing posteroinferiorly toward the area just superior to the oval window. The segment may be dehiscence, and the facial nerve may be exposed to the tympanic cavity. Around the posterior edge of the oval window and medial to the short process of the incus, the nerve follows gentle curve directing inferiorly. The curve is called the second genu, located inferomedially to the LSC. The mastoid segment of the nerve runs nearly vertically toward the stylomastoid foramen that is located anteriorly to the digastric ridge. Therefore, the mastoid segment of the nerve courses near the line between the short process of the incus and the digastric ridge, and in the posterior wall of the tympanic cavity. On the anterior surface of the mastoid segment, the stapedius muscle receives its innervation from the facial nerve.

The chorda tympani branches from the nerve at last, usually before the nerve exits from the stylomastoid foramen. It ascends in the posterior wall of the tympanic cavity at the canaliculus chordae tympani, and emerges into the tympanic cavity near the chordal crest. It courses laterally to the long process of the incus and medially to the neck of the malleus, and exits from the cavity through the petrotympanic fissure.

One of the most serious complications in the middle ear surgery is injury to the facial nerve. The surgeon must have complete knowledge about anatomical relationships of the nerve and surrounding structures. Positive identification of the nerve in the surgical field considerably reduces risks to injure it. Therefore, surgeon should always be prepared for identifying the nerve at any segments using available landmarks. Anomalies of the nerve should always be kept in mind. The nerve may be located inferiorly to the oval window, or may be divided into branches.

1.8.1 Landmarks and Signs for Positive Identification

- The digastric ridge points directly to the nerve at the stylomastoid foramen. The facial nerve courses perpendicular to the ridge.
- The lateral semicircular canal. The facial nerve runs anteriorly to the canal and almost always medially to the level of it. The short process of the incus lies laterally to the nerve.
- The oval window niche, with the nerve lying superior to it. Care should be taken not to mistake the canal of the tensor tympani for the tympanic segment of the nerve. The canal of the tensor tympani muscle is horizontal, ending at the cochleariform process, while the nerve courses obliquely in the tympanic cavity.
- The cochleariform process. The nerve runs directly superior to it. Since it is resistant to cholesteatoma and often identifiable in revision surgery, the cochleariform process is a very important and consistent landmark.
- The cog points to the facial nerve in the floor of the anterior epitympanic recess.

- Bleeding usually occurs when the nerve sheath is exposed. Any tubular bleeding structure should be suspected to be the facial nerve until proved otherwise. A useful method is to gently probe the suspicious structure with a blunt instrument. The facial nerve will return to its place when the instrument is removed.
- Patients usually complain of some discomfort when the chorda tympani nerve is insulted under local anesthesia. This is informative when the facial ridge is lowered.
- The facial nerve courses inferolaterally in the third portion, which makes the nerve run more laterally, closer to the tympanic annulus inferiorly. The distance between the nerve and the annulus is only 2 to 3 mm, and the nerve may run laterally to the tympanic annulus inferiorly. The relationship is of tremendous importance especially in meatoplasty.

Refer to ► Fig. 1.1, ► Fig. 1.2, ► Fig. 1.3, ► Fig. 1.4, ► Fig. 1.5, ► Fig. 1.6, ► Fig. 1.7, ► Fig. 1.8, ► Fig. 1.9, ► Fig. 1.10, ► Fig. 1.11, ► Fig. 1.12, ► Fig. 1.13, ► Fig. 1.14, ► Fig. 1.15, ► Fig. 1.16, ► Fig. 1.17, ► Fig. 1.18, ► Fig. 1.19, ► Fig. 1.20, ► Fig. 1.21.

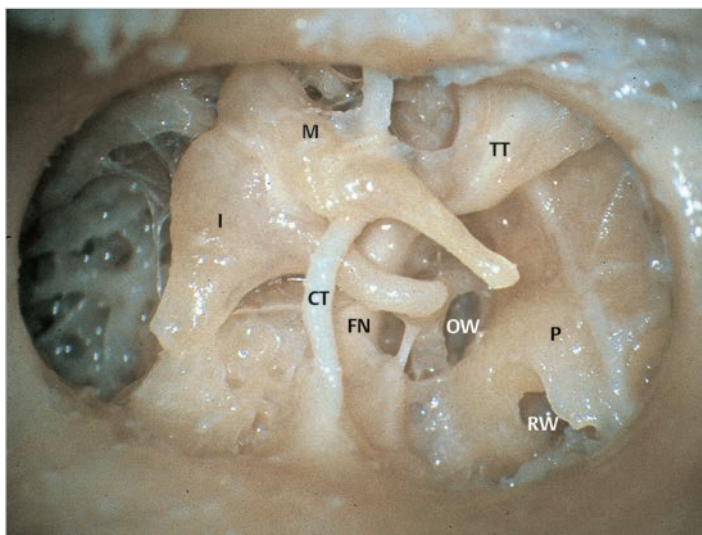


Fig. 1.1 The structures in the right tympanic cavity are shown after performing atticotomy and partially removing the posterior canal wall. The bone is placed in the similar way to the surgery. Important structures in the medial wall of the middle ear are shown. CT, chorda tympani; FN, facial nerve; I, incus; M, malleus; OW, oval window; P, promontory; RW, round window niche; TT, tensor tympani.

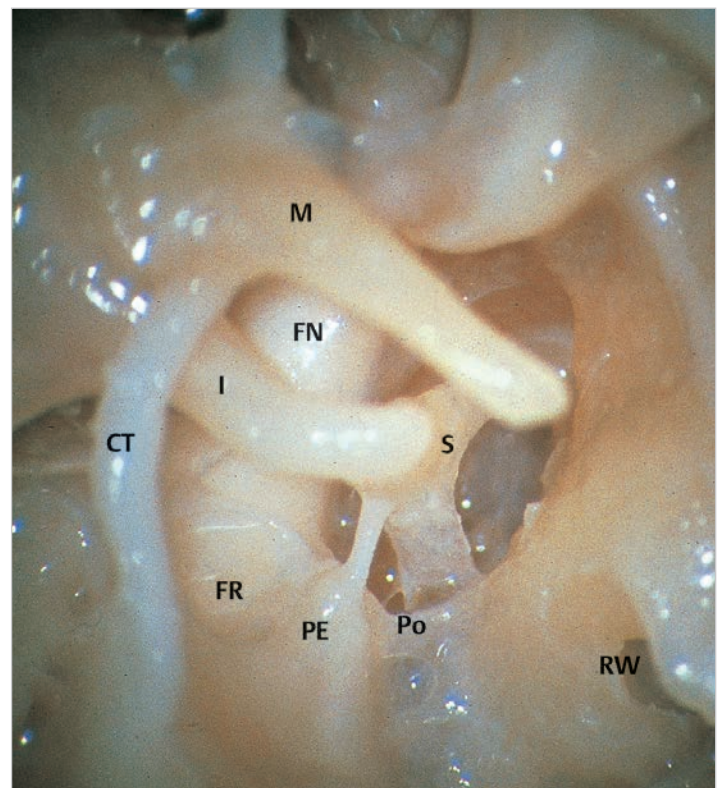


Fig. 1.2 In higher magnification. CT, chorda tympani; FN, facial nerve; FR, facial recess; I, incus; M, malleus; PE, pyramidal eminence; Po: ponticulus; RW; round window niche; S, stapes; TS, tympanic sinus.

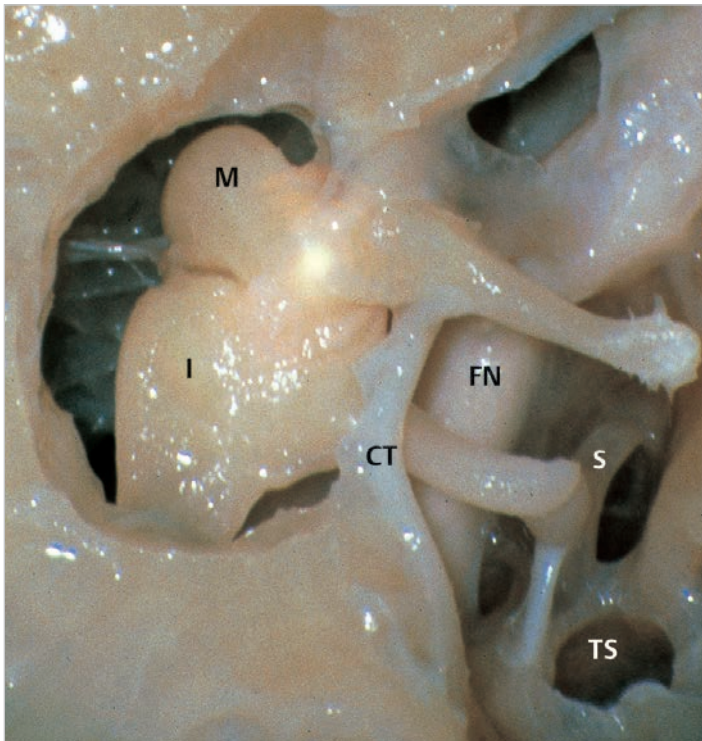


Fig. 1.3 The structures seen after small atticotomy are shown. CT, chorda tympani; FN, facial nerve; I, incus; M, malleus; S, stapes; TS, tympanic sinus.

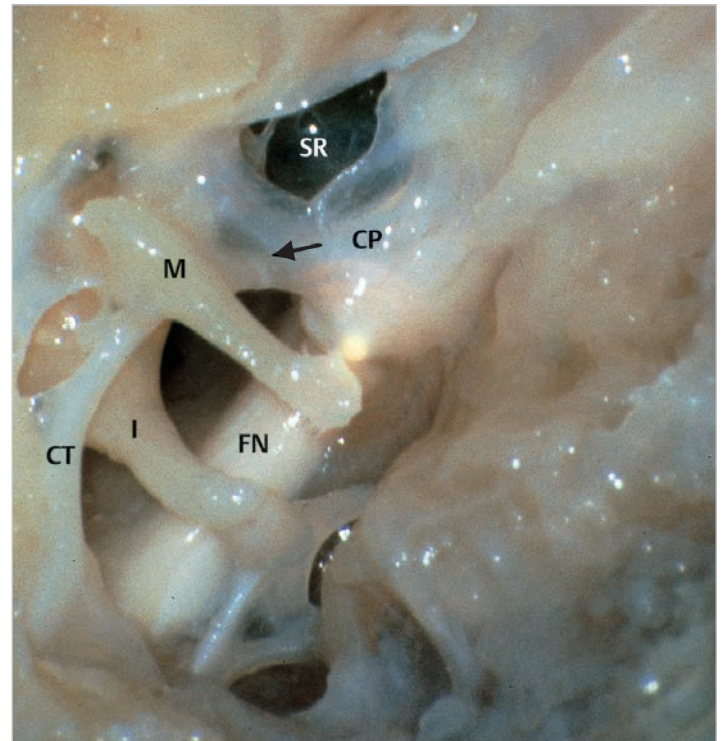


Fig. 1.4 Structures in the medial wall of the mesotympanum as viewed from anteroinferior direction. The tendon of the tensor tympani is seen (arrow). Note the protrusion of the facial nerve and its proximity to the round window. CP, cochleariform process; CT, chorda tympani; FN, facial nerve; I, long process of the incus; M, manubrium of the malleus; SR, supratubal recess.

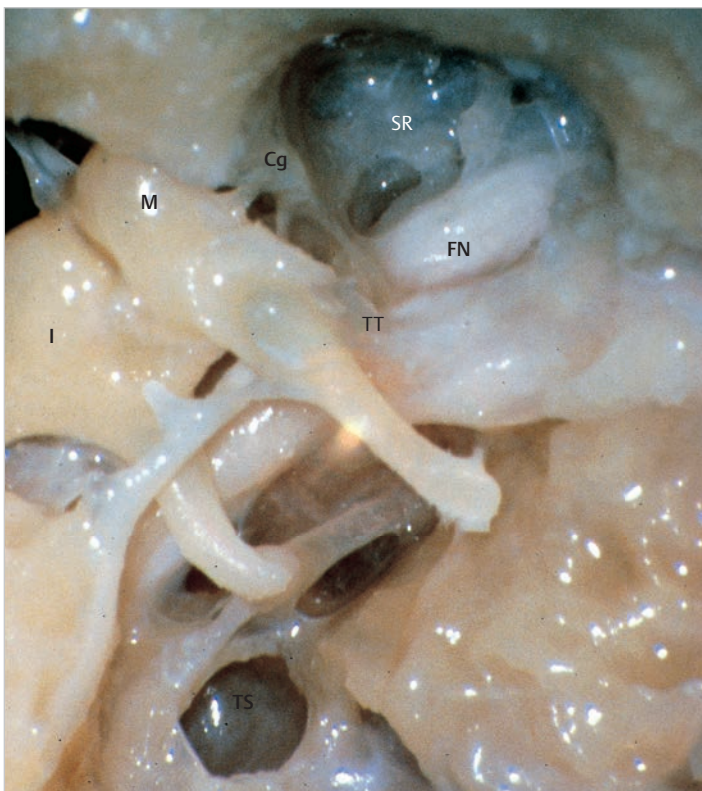


Fig. 1.5 The lateral wall of the supratubal recess is opened and the medial wall is seen from anterolaterally. The cog, located just anterior to the head of the malleus divides the supratubal recess from the attic. In the bottom of the recess, pregeniculate portion of the facial nerve is seen. The nerve runs immediately superior to the tensor tympani muscle. Cg, cog; FN, facial nerve; I, incus; M, malleus; SR, supratubal recess; TS, tympanic sinus; TT, tensor tympani muscle.

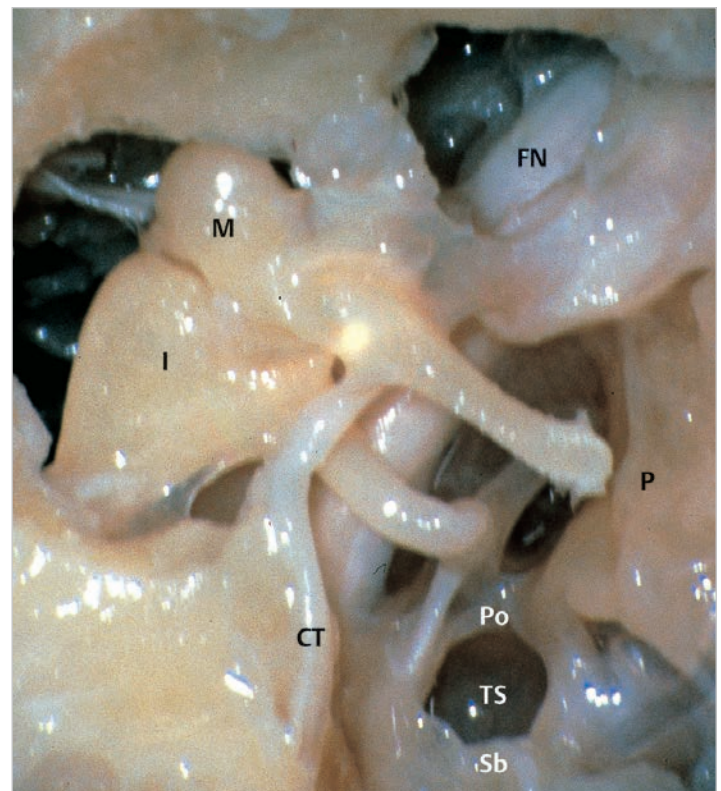


Fig. 1.6 Another view of the same specimen. The tympanic sinus is located anteroinferiorly to the facial nerve, and the facial recess is located just lateral to the nerve. Deep tympanic sinus and large anterior attic recess are shown. The tympanic sinus is divided into two parts by the ponticulus. The tympanic sinus is bordered inferiorly by the subiculum. CT, chorda tympani; FN, facial nerve; I, incus; M, malleus; P, promontory; Po, ponticulus; Sb, subiculum; TS, tympanic sinus.

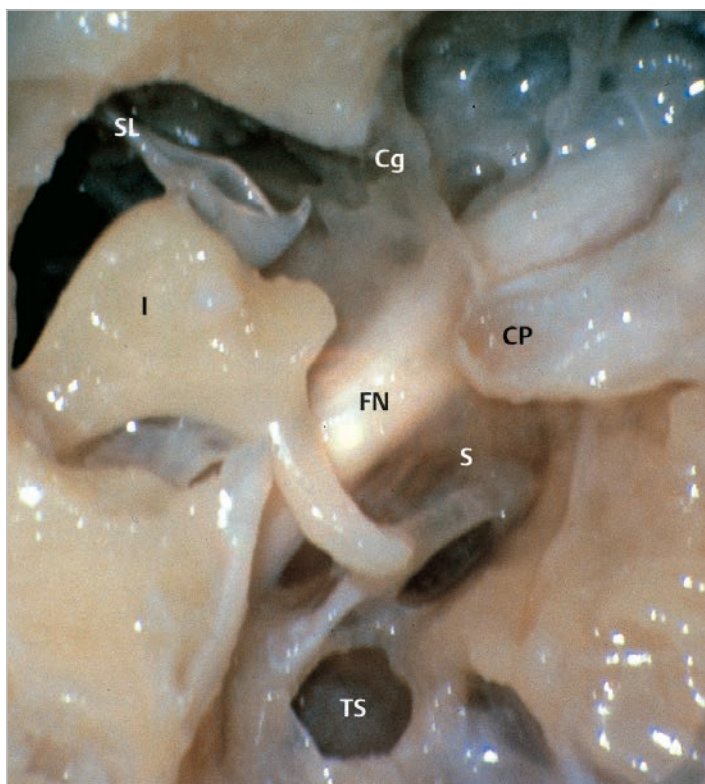


Fig. 1.7 The malleus is removed and the supratubal recess is opened laterally. The cog separating the recess from the attic is clearly seen. The pregeniculate portion of the facial nerve is located in the bottom of the supratubal recess anteriorly to the malleus, and runs between the cog and the cochleariform process. Cg: cog; CP, cochleariform process; FN, facial nerve; I, incus; S, stapes; SL, superior suspensory ligament; TS, tympanic sinus.

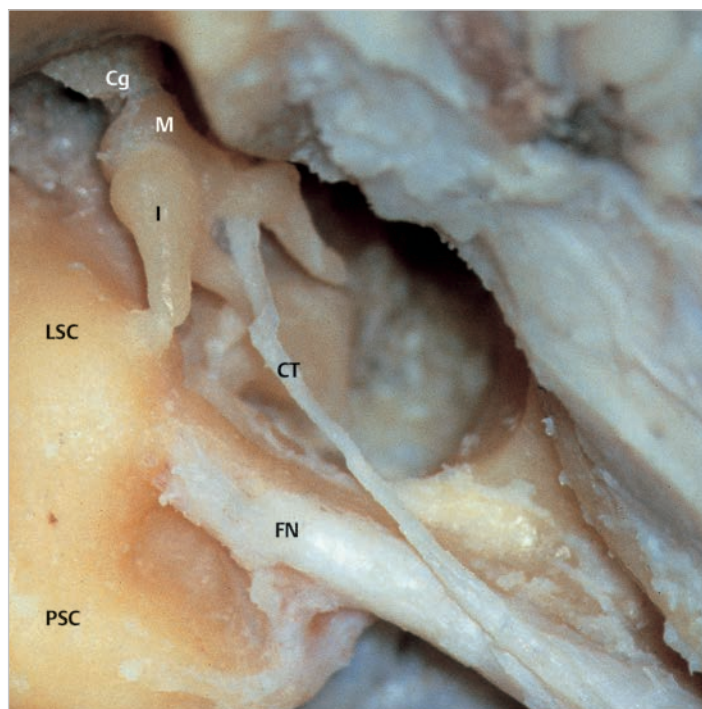


Fig. 1.8 Posterior canal wall and the tympanic membrane are removed. Semicircular canals are skeletonized. The chorda tympani enters the tympanic cavity through the posterior wall, and runs laterally to the long process and medially to the neck of the malleus. Cg, cog; CT, chorda tympani; FN, facial nerve; I, incus; LSC, lateral semicircular canal; M, malleus; PSC, posterior semicircular canal.

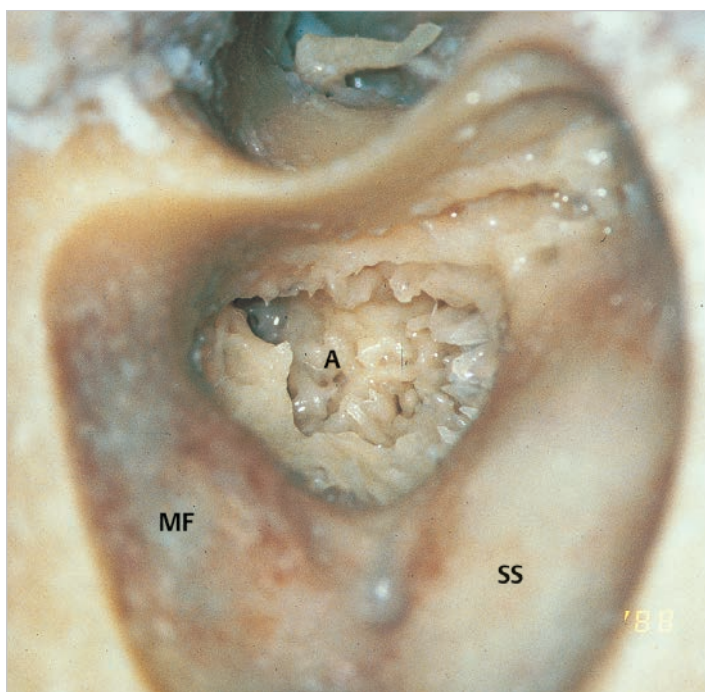


Fig. 1.9 The mastoidectomy is carried out and the antrum is opened. Note that the middle fossa plate and the sigmoid sinus plate are thinned and clearly identified. A, antrum; MF, middle fossa plate; SS, sigmoid sinus.

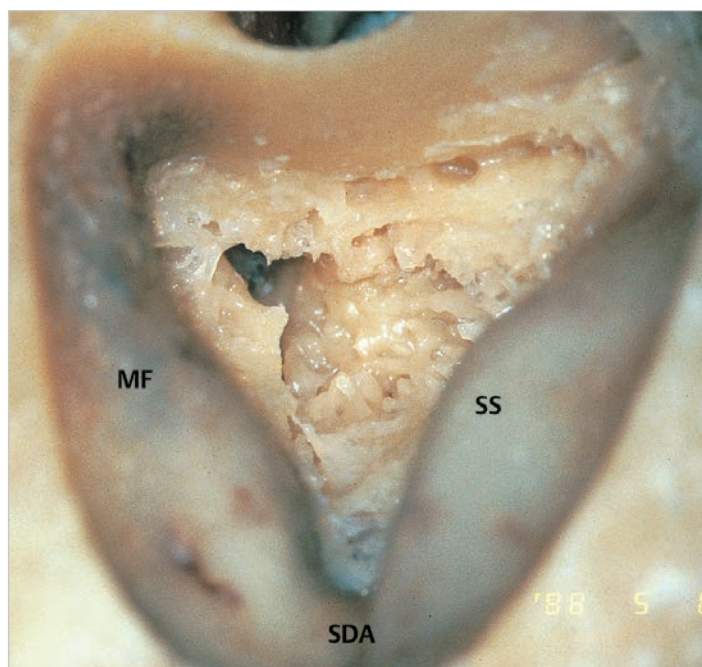


Fig. 1.10 The sinodural angle is sufficiently opened, and bone covering the antrum is gradually removed. In this case, the middle cranial fossa dura is low, and the sigmoid sinus is advanced anteriorly, making the sinodural angle narrow. Careless removal of the bony overhang from the lateral wall of the antrum may cause sensorineural hearing loss by touching the chain with a burr head. MF, middle fossa plate; SDA, sinodural angle; SS, sigmoid sinus.

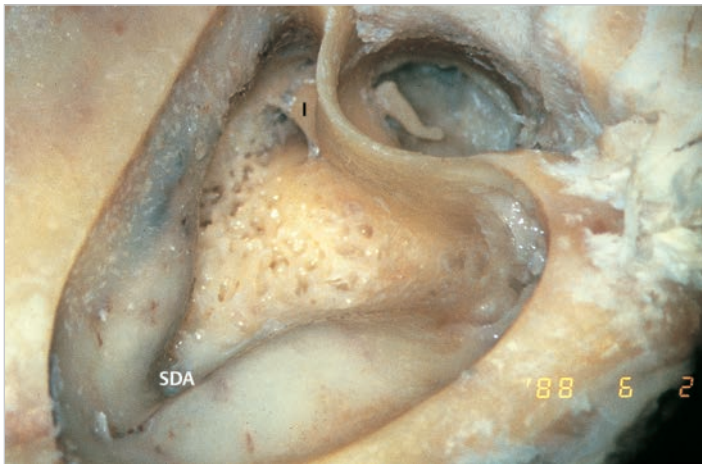


Fig. 1.11 The attic is opened. The incus and the malleus are seen. The tympanic membrane and the canal skin are removed in this bone. I, incus; SDA: sinodural angle.

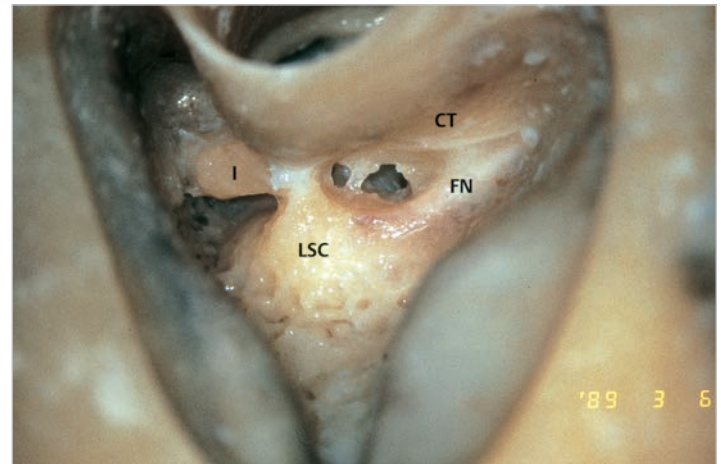


Fig. 1.12 The facial nerve and the chorda tympani are skeletonized. Posterior tympanotomy is partially carried out by removing bone between two nerves. CT, chorda tympani; FN, facial nerve; I, incus; LSC, lateral semicircular canal.

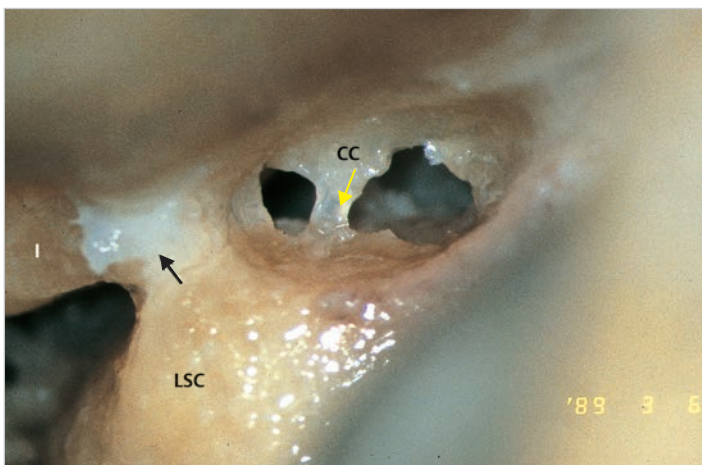


Fig. 1.13 The posterior tympanotomy is viewed in higher magnification. The chordal crest is seen as a bony bridge crossing the tympanotomy (yellow arrow). The incus is protected by leaving a small bony bridge that corresponds to the bottom of the fossa incudis posterior to it. The short process is anchored to the bridge by the posterior incudal ligament (black arrow). CC, chordal crest; I, incus; LSC, lateral semicircular canal.

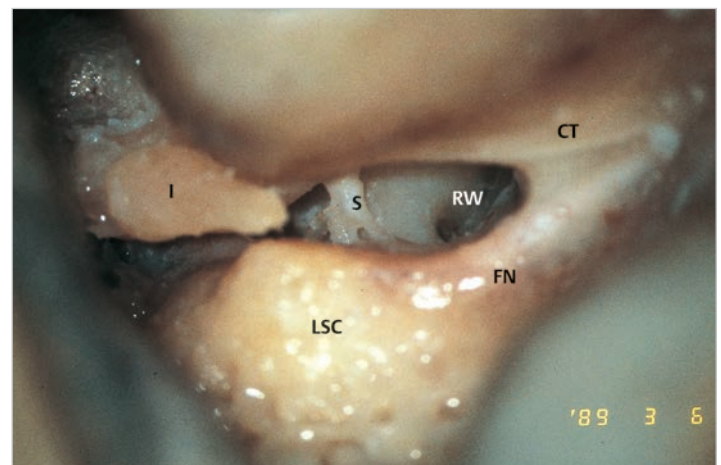


Fig. 1.14 The posterior tympanotomy is completed. The chordal crest and the bony bridge posterior to the incus are removed. The stapes superstructure and the round window niche are now visible. CT, chorda tympani; FN, facial nerve; I, incus; LSC, lateral semicircular canal; RW, round window niche; S, stapes.

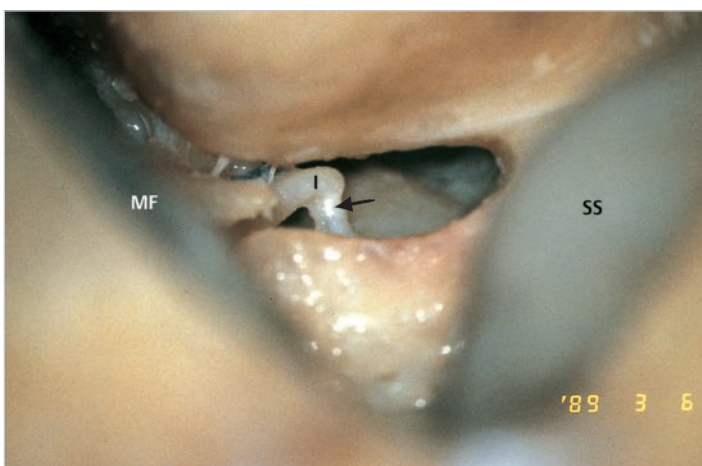


Fig. 1.15 The posterior tympanotomy viewed through the sinodural angle. The incudostapedial joint is seen (arrow). Note that since the middle fossa dura is low and the sigmoid sinus is narrow, access through the posterior tympanotomy is limited by these two structures. This may be problematic if intensive management of the tympanic cavity through the posterior tympanotomy is required. I, long process of the incus; MF, middle fossa plate; SS, sigmoid sinus.

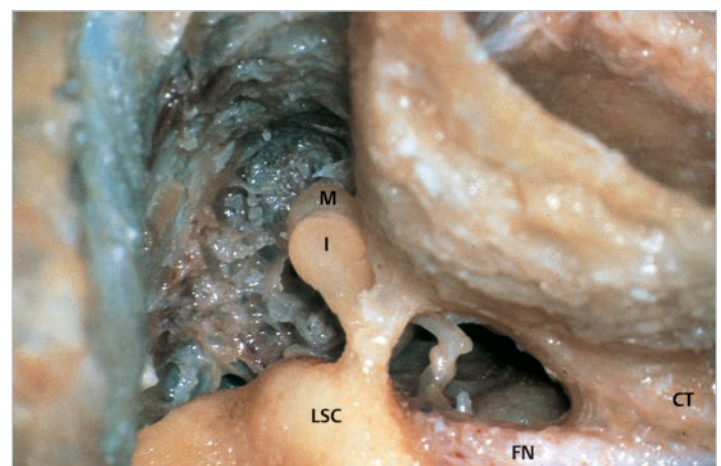


Fig. 1.16 Canal wall up technique in another temporal bone is shown. The posterior epitympanotomy and posterior tympanotomy are completed, and the medial wall of the attic anterior to the semicircular canals is drilled. The ossicular chain and the area of the oval window are seen. CT, chorda tympani; FN, facial nerve; I, incus; LSC, lateral semicircular canal; M, malleus.

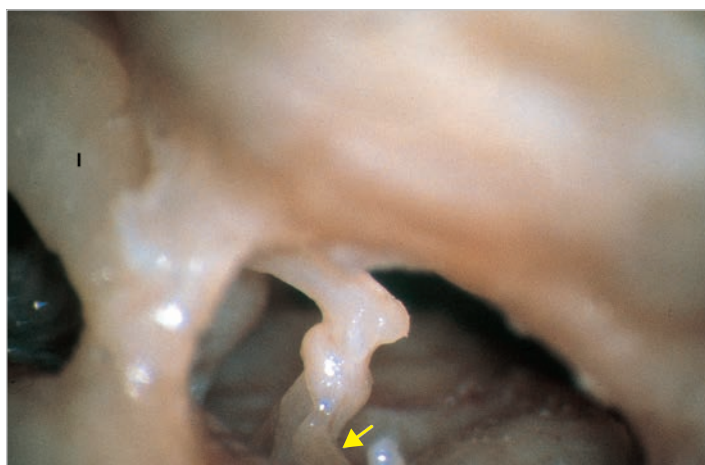


Fig. 1.17 In higher magnification, the incus is seen through the attic and the posterior tympanotomy. View of the area of the oval window is obtained through the posterior tympanotomy. The arrow indicates the pyramidal eminence with tensor tympani tendon. I, incus.

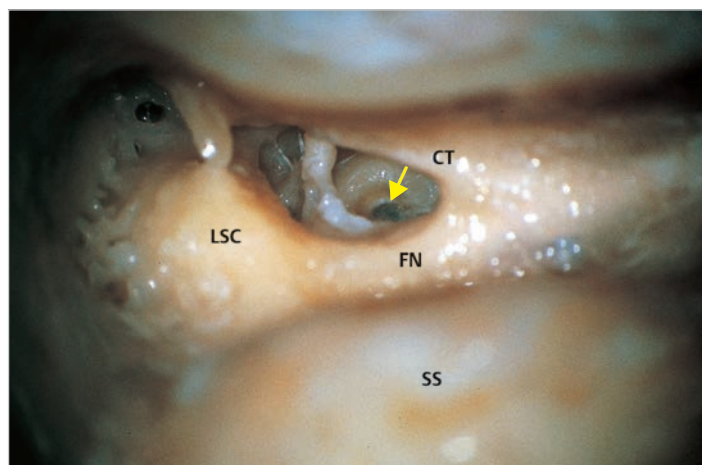


Fig. 1.18 Posterior tympanotomy in a different bone is shown. The round window niche is seen through the posterior tympanotomy (arrow). CT, chorda tympani; FN, facial nerve; LSC, lateral semicircular canal; SS, sigmoid sinus.

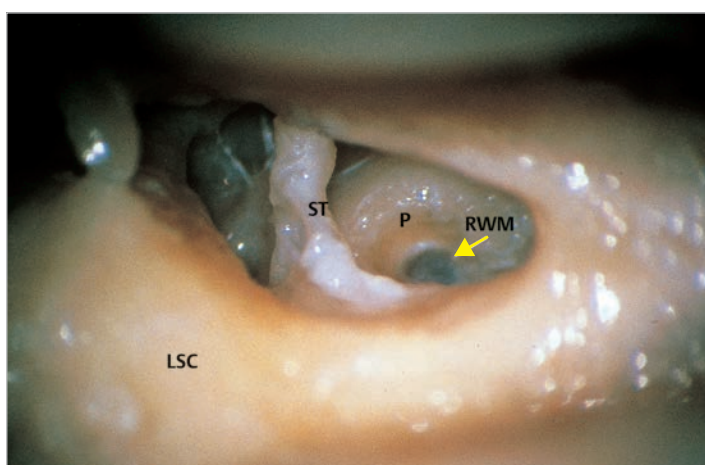


Fig. 1.19 In higher magnification, the tympanic segment of the facial nerve running in the tympanic cavity is seen. The round window is seen clearly through the posterior tympanotomy. It is located inferiorly to the oval window and posteroinferiorly to the promontory. The round window membrane can be seen directly in some cases (arrow). LSC, lateral semicircular canal; P, promontory; RWM, round window membrane; ST, stapedial tendon.

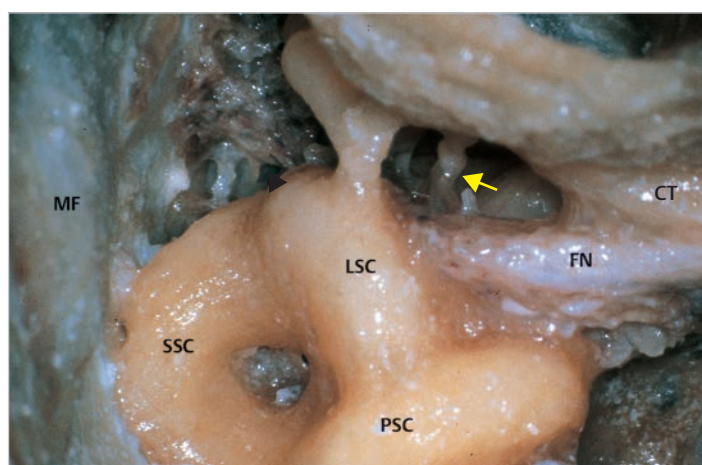


Fig. 1.21 The stapes' superstructure and the incudostapedial joint are seen (arrow). The second genu of the facial nerve is located just inferomedial to the lateral semicircular canal, and just medial to the short process of the incus. The semicircular canals are positioned perpendicularly to each other. The superior semicircular canal is located just beneath the middle fossa dura. CT, chorda tympani; FN, facial nerve; LSC, lateral semicircular canal; MF, middle fossa plate; PSC, posterior semicircular canal; SSC, superior semicircular canal.

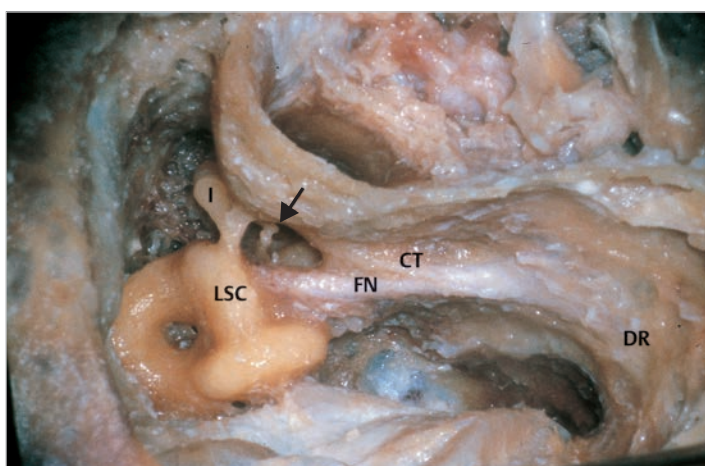


Fig. 1.20 Bone around the posterior labyrinth is removed, the mastoid segment of the facial nerve is exposed, and the dura of the posterior fossa is uncovered. Note that the facial nerve runs just anterior to the digastric ridge, and just inferomedial to the lateral semicircular canal. CT, chorda tympani; DR, digastric ridge; FN, facial nerve; I, incus; LSC, lateral semicircular canal.

1.9 Computed Tomography of the Temporal Bone and Related Anatomy

Middle ear surgeons should know advantages and drawbacks of both magnetic resonance imaging (MRI) and computed tomography (CT) scan, to choose appropriate modality depending on nature and status of pathology.

The CT surpasses MRI regarding space resolution and contrast between bone, soft tissue, and air. Multislice high-resolution CT allows precise demonstration of fine middle ear structures such as ossicular chain and inner ear, with thin slices of less than 1 mm in short time. Preoperative identification of pathological status such as extension, erosion of the ossicular chain, labyrinthine fistulas, exposed dura, exposed facial nerve, ossification around the ossicular chain, and ossification covering cholesteatoma helps to plan surgical strategies and to reduce surgical risks. The CT also gives the surgeon chances to recognize anatomical variation such as low middle cranial fossa dura, protruded sigmoid sinus, high jugular bulb, and highly pneumatized mastoid. For most of preoperatively known middle ear pathology, preoperative high-resolution CT is the modality of choice, and is necessary especially in cholesteatoma surgery. For example, some cases of cholesteatoma are far more advanced than expected from both otoscopic and physiological examinations. In such cases, it is important to inform the patient individualized risk of surgery, or it might be necessary to refer to a right surgeon.

Lack of signal from both bone and air and insufficient space resolution in MRI disallow identification of middle ear structures, and limit its necessity in middle ear surgery. On the other hand, MRI excels in contrast between various soft tissues, and is necessary for differential diagnosis and staging of neoplastic, petrous apex, and intracranial lesions. Since the device develops so quickly, the MRI might play some important role in middle ear surgery. For example, after cholesteatoma surgery, it is not always possible to discriminate between residual cholesteatoma and postoperative change with CT, and surgeons should choose close radiological follow-up or surgery depending on the amount of suspicion. Non-echo-planer diffusion-weighted image MRI (turbo spin-echo diffusion-weighted image MRI) is reported to have potential to distinguish cholesteatoma from other tissue, and such kind of new technique could replace unnecessary second-look surgery and repetitive radiological exposure in near future.

It is important to know limitation of radiological diagnosis. Blind confidence in radiological reports is definitely prohibited due to limited number of radiologists who have sufficient knowledge about temporal bone anatomy and pathology. To avoid misdiagnosis, surgeons themselves should be prepared to interpret the radiogram. Even in cases where detailed CAT or CT scans are available, presence of labyrinthine fistulae should be assumed in every case of cholesteatoma, since some of them are not demonstrated, or not noticed especially when fistulae are present somewhere other than the LSC.

These two modalities, CT and MRI, are currently complementary, and surgeons need to choose right one, or both, for good management. Surely, accessibility and cost for MRI should be concerned. Meticulous and repetitive investigation of CT with/

without pathology helps to understand 3D anatomy of the temporal bone, since it constantly gives precise anatomical relationships between important structures which are not seen in common middle ear surgery.

1.9.1 Axial Sections

Refer to ► Fig. 1.22, ► Fig. 1.23, ► Fig. 1.24, ► Fig. 1.25.

Slice 1: To avoid missing pathological findings, it is important to observe entire temporal bone. In the horizontal sections of CT scan, the top of the SSC visualized as a straight line in the compact bone directing anterolateral to posteromedial should be found at the beginning.

Slice 2: Because of its ringed shape, SSC is separated into two dots located anterolaterally and posteromedially.

Slice 3: The subarcuate artery arising from the posterior cranial fossa passes through SSC.

Slice 4: The superior end of the PSC branches from the posterior end of the SSC. Note that in the horizontal plane, PSC is arranged perpendicularly to SSC, with its open angle directing just lateral.

Slice 5: The ampulla of the SSC is located in its anterior end of SSC, and the posterior end joins the PSC to form the common crus. This slice also visualized the superior aspect of the internal auditory canal, where the labyrinthine segment of the facial nerve leaves the fundus of it directing anterolaterally toward the geniculate ganglion. Since the labyrinthine segment is always clearly identified radiologically due to encompassing compact bone (otic capsule) and its characteristic appearance, the segment is ideal starting point to follow the course of the facial nerve in CT. The posterior semicircular canal is visualized as a dot separated from the common crus. The vertical crest visualized clearly in the next slice is started to be seen posteriorly to the labyrinthine segment.

Slice 6: The slice visualized the ringed shape of the LSC clearly. Its ampulla is located at the anterior end just beneath the ampulla of the SSC. The ossicular chain is started to be visualized. The head of the malleus is located anteriorly, and the body of the incus is located posteriorly. The geniculate ganglion is seen anteromedially to the ossicles. The aditus ad antrum connects the attic with the antrum. Thin bony lamina separating the superficial mastoid air cells from deeper cells including the antrum is called Körner's septum. The septum, even though it is not present always, corresponds to the petrosquamous suture, and air cells lateral to it belong to the squamous part of the temporal bone. Beginners may waste time if they mistake Körner's septum for the medial wall of the antrum. The fundus of the internal auditory canal is divided into two parts, superiorly and posteriorly with a high bony crest called horizontal crest (see Slice 25). The superior half of the fundus is subdivided into two with a lower crest called vertical crest. The facial nerve runs in the anterior division, and the posterior division contains the superior vestibular nerve innervating ampullae of SSC and LSC, and the utricles. The vestibular aqueduct runs posteriorly to the PSC to reach the endolymphatic sac located on the posterior fossa dura.

Slice 7: This is the level where representative "cone and ice cream" shape of the incus-malleus complex is seen just lateral to the tympanic segment of the facial nerve. Course of the nerve

passing just inferomedially to the LSC is also visualized. The cavity located medially to the LSC is the vestibule. The superior aspect of the cochlea is started to be visualized in the compact otic capsule. Note that the vestibule is located relatively higher than the cochlea. The space that accommodates the short process of the incus located just inferolateral to the LSC is called fossa incudis. Since the tip of the short process comes lateral toward the surgeon, and the lateral wall of the fossa incudis is very close, the tip of the short process is easily touched with the bur in inattentive maneuvers.

Slice 8: The cochleariform process is visualized just inferiorly to the slice 8 shows the structures in the level of the cochleariform process where the tendon of the tensor tympani muscle arises. The tensor tympani muscle is seen anteriorly to the process. The facial nerve passing just superiorly to the process is moving to the posterior wall of the tympanic cavity.

Slice 9: The slice well visualized the main part of the stapes and important structures around it. The long process of the incus approaches to the stapes. The tensor tympani muscle is accommodated in the semicanal to form the roof of the eustachian tube, and its tendon is directed laterally at the cochleariform process to reach the neck of the malleus. The cochleariform process is located just anterior to the footplate. The pyramidal eminence from which the tendon of the stapedial muscle emerges is located just on the anterior face of the facial nerve. The dip under the eminence and posteriorly to the stapes corresponds to the tympanic sinus. The inferior end of the posterior semicircular canal together with its ampulla is located near the bottom of the tympanic sinus. A fine channel branching from the internal corresponds to the singular nerve that branches from the inferior vestibular nerve and innervates the ampulla of the PSC.

Slice 10: Since the stapes is tilted inferiorly, the incudostapedial joint connecting the head of the stapes and the lenticular process on the long process of the incus is visualized in the slice just inferiorly to the superstructure. As seen, the bottom of the tympanic sinus is completely covered by the facial nerve, and is not accessible directly from lateral. The axis of the cochlea directs anterolaterally, and the basal turn of the cochlea is clearly divided from the apical two turns by thick bone.

Slice 11: The slice visualized the round window niche. The border between the inner ear fluid in the basal turn and the air in the niche corresponds to the round window membrane. The promontory corresponds to the basal turn of the cochlea. The stapedial muscle courses just medially to the facial nerve and receives innervation, two soft tissue in vicinity. Therefore, whenever two soft tissue bundles are identified in the posterior wall of the tympanic cavity, the lateral one corresponds to the facial nerve, and the medial one corresponds to the stapedial muscle. The top of the jugular bulb is visualized.

Slice 12 to 18: The fine channel visualized between the jugular bulb and the cochlea corresponds to the cochlear aqueduct connecting the subarachnoid space to the basal turn of cochlea near the round window. The aqueduct originates from the anterosuperior part of the jugular foramen. The carotid artery enters the

skull base through the carotid canal located anteromedially to the jugular foramen, and ascends toward the anterior part of the tympanic cavity. It turns anteromedially at nearly a right angle near the anteroinferior aspect of the cochlea, passing the posterior wall of the eustachian tube, to reach the petrous apex (horizontal portion). Access to the petrous apex might be established through the hypotympanic cells, between the carotid artery, the jugular bulb, and the cochlea. Anteriorly to the petrous apex, several channels in the middle fossa can be identified. The foramen ovale transmits the third branch of the trigeminal nerve (mandibular nerve). The foramen rotundum transmits the second branch of the nerve (maxillary nerve), and the foramen spinosum transmits the middle meningeal artery.

1.9.2 Coronal Sections

Refer to ► Fig. 1.26, ► Fig. 1.27, ► Fig. 1.28.

Slice 19, 20: Since the bony portion of the external auditory canal curves anteriorly, anterior tympanomeatal angle is seen in the first slice. The great superficial petrosal nerve branching from the geniculate ganglion is visualized. The tensor tympani muscle covers the apex of the cochlea. The vertical portion of the carotid artery turning near the cochlea to form the horizontal portion is visualized.

Slice 21 to 23: After leaving the fundus of the internal auditory canal, the labyrinthine segment penetrates compact otic capsule, and joins the geniculate ganglion near the level of the cochleariform process. The tendon of the tensor tympani muscle emerging the tympanic cavity to reach the malleus is visualized. Since the labyrinthine segment of the facial nerve directs anterolaterally before making sharp turn at the geniculate ganglion, two parts of the facial nerve are visualized in the same slice as far as the labyrinthine segment is present. Note the proximity of the facial nerve and the cochleariform process. The nerve runs just superiorly to the process. These slices show relationships between the cochleariform process. As shown, the incus always covers the head of the malleus from lateral.

Slice 24, 25: The thin bony shell located at the bottom of the bony dip between the facial nerve and the promontory corresponds to the footplate. The footplate forms the lateral wall of the vestibule. The head of the stapes is also seen in the air. The short process of the incus is accommodated in the fossa incudis, just inferolateral to the eminence of LSC. Note the proximity of the lateral wall to the short process. The ampulla of the SSC is located just superiorly to the one of the LSC. The boundary between soft tissue and the air at the top of the round window niche corresponds to the round window membrane. The horizontal crest divides the fundus of the internal auditory canal. The facial nerve and the superior vestibular nerve pass the superior compartment, and the cochlear nerve pass the inferior.

Slice 26 to 29: The facial nerve courses inferomedially to the LSC. The stapedial muscle runs medially to the facial nerve, and the tympanic sinus is located medially to the pyramidal eminence and the muscle. At the bottom of the tympanic sinus, the ampulla of the PSC is located.

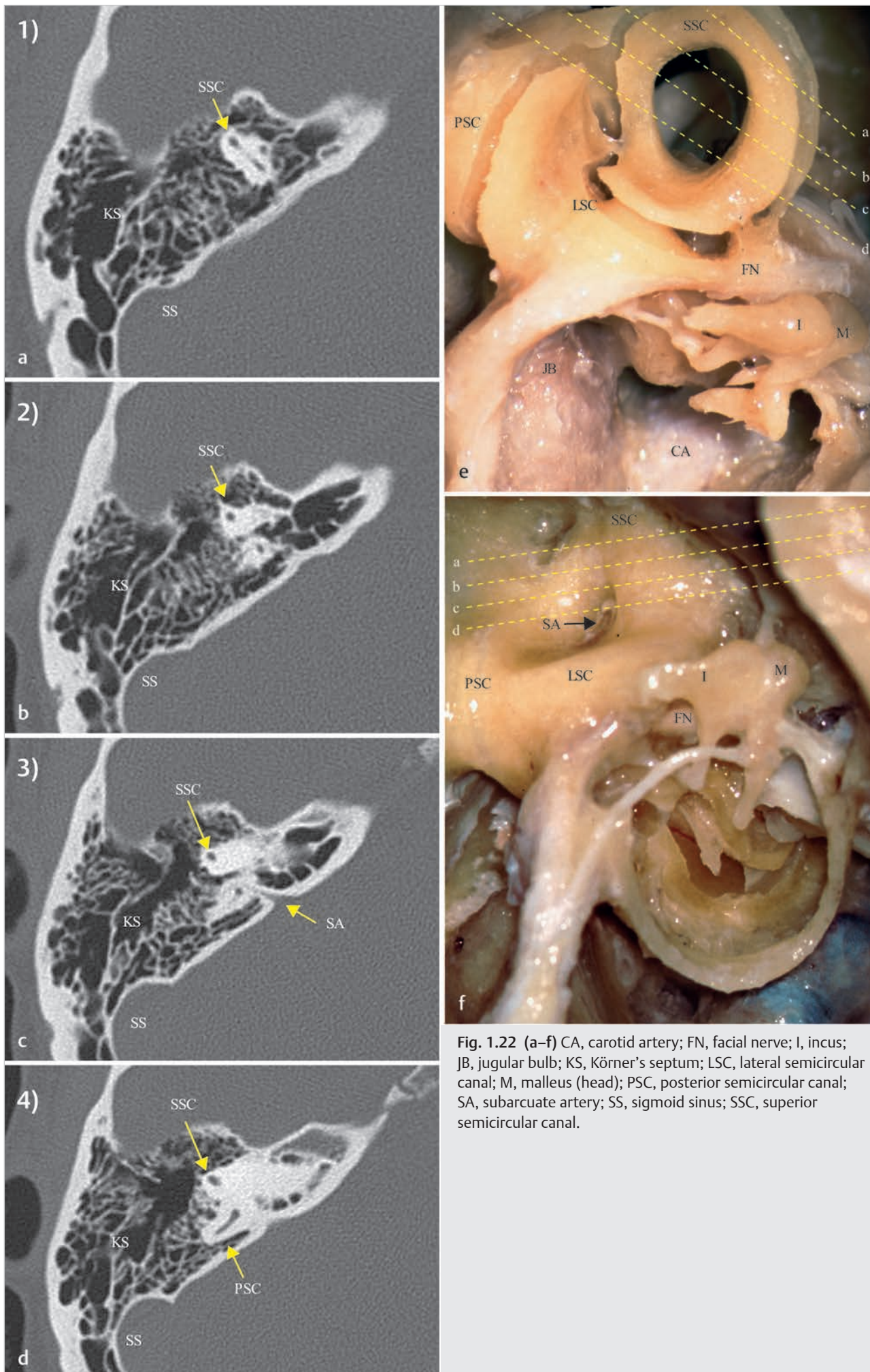
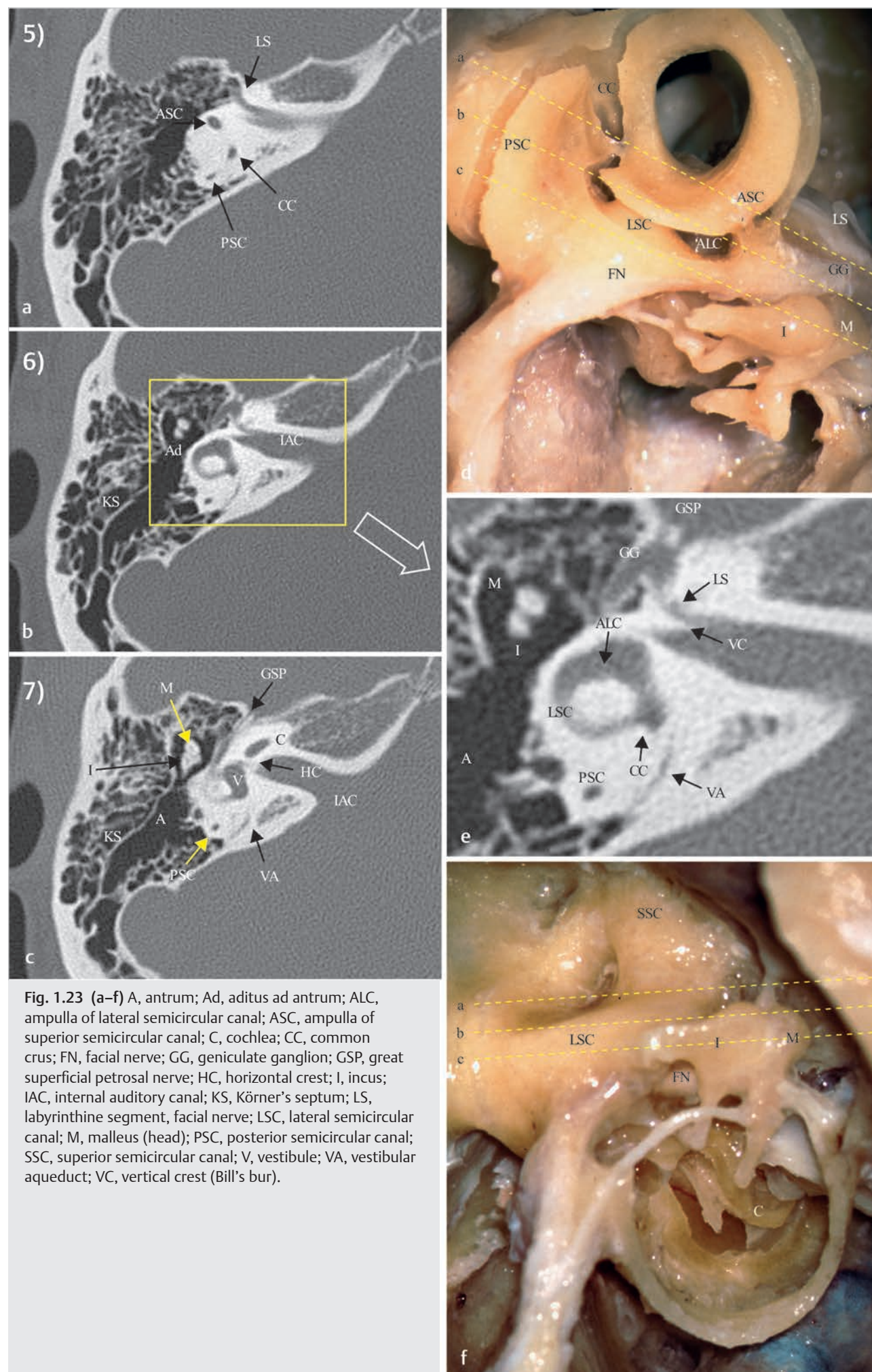


Fig. 1.22 (a-f) CA, carotid artery; FN, facial nerve; I, incus; JB, jugular bulb; KS, Körner's septum; LSC, lateral semicircular canal; M, malleus (head); PSC, posterior semicircular canal; SA, subarcuate artery; SS, sigmoid sinus; SSC, superior semicircular canal.



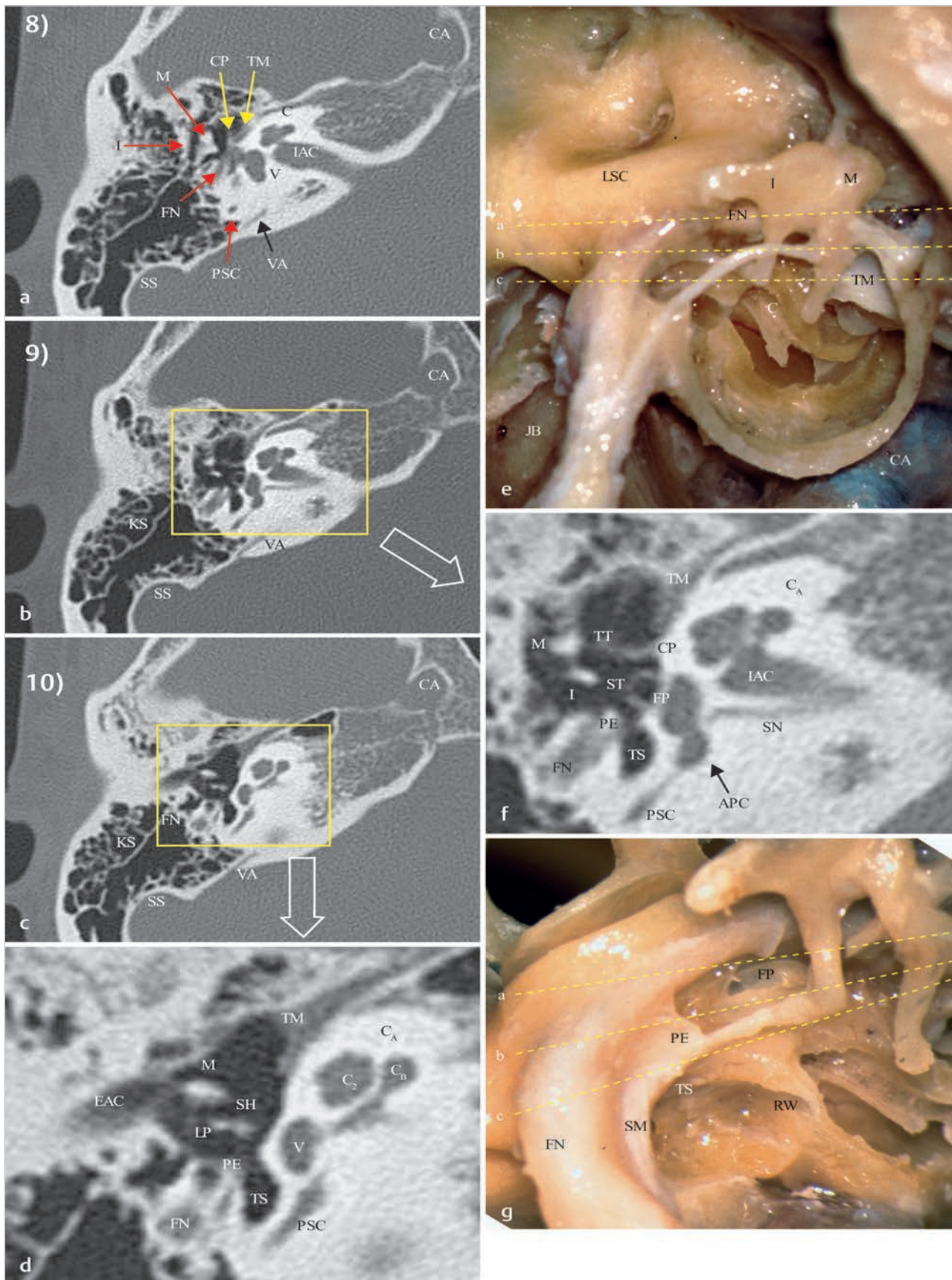


Fig. 1.24 (a–i) APC, ampulla of posterior semicircular canal; C, cochlea; CA, carotid artery; CA_Q, cochlear aqueduct; C_A, apical turn of cochlea; C_B, basal turn of cochlea; C₂, second turn of cochlea; CP, cochleariform process; EAC, external auditory canal; EV, emissary vein; FN, facial nerve; FP, footplate of stapes; FR, foramen rotundum; I, incus; IAC, internal auditory canal; JB, jugular bulb; KS, Körner's septum; LP, lenticular process of incus; LSC, lateral semicircular canal; M, malleus; P, promontory; PE, pyramidal eminence; PSC, posterior semicircular canal; RW, round window; SH, head of stapes; SL, spiral lamina; SM, stapedial muscle; SN, canal for singular nerve; SS, sigmoid sinus; ST, stapes; TM, tensor tympani muscle; TMJ, temporomandibular joint; TS, tympanic sinus; TT, tendon of tensor tympani muscle; V, vestibule; VA, vestibular aqueduct.

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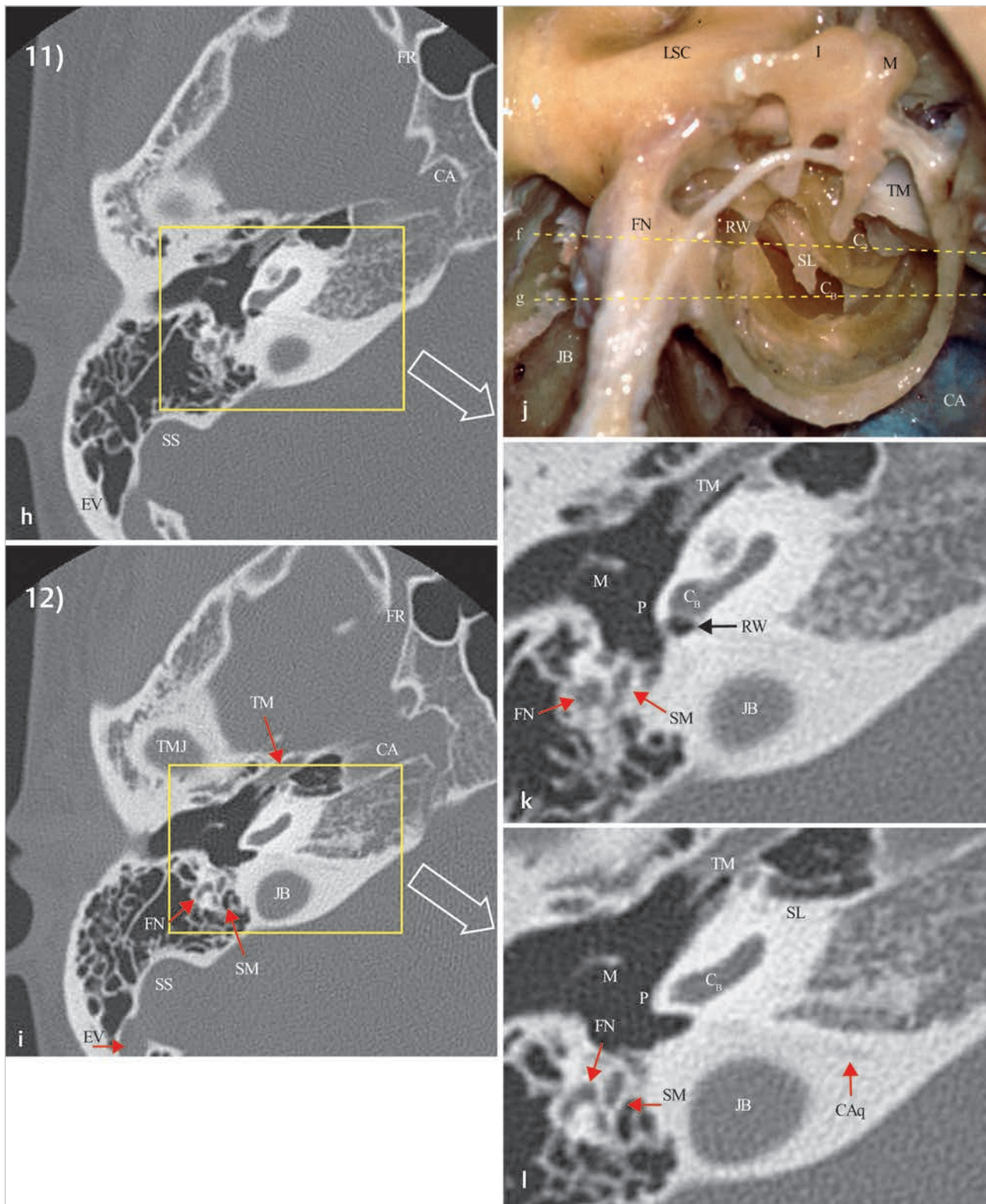


Fig. 1.24 (continued) (a–l) APC, ampulla of posterior semicircular canal; C, cochlea; CA, carotid artery; CA_q, cochlear aqueduct; C_A, apical turn of cochlea; C_b, basal turn of cochlea; C₂, second turn of cochlea; CP, cochleariform process; EAC, external auditory canal; EV, emissary vein; FN, facial nerve; FP, footplate of stapes; FR, foramen rotundum; I, incus; IAC, internal auditory canal; JB, jugular bulb; KS, Körner's septum; LP, lenticular process of incus; LSC, lateral semicircular canal; M, malleus; P, promontory; PE, pyramidal eminence; PSC, posterior semicircular canal; RW, round window; SH, head of stapes; SL, spiral lamina; SM, stapedial muscle; SN, canal for singular nerve; SS, sigmoid sinus; ST, stapes; TM, tensor tympani muscle; TMJ, temporomandibular joint; TS, tympanic sinus; TT, tendon of tensor tympani muscle; V, vestibule; VA, vestibular aqueduct.

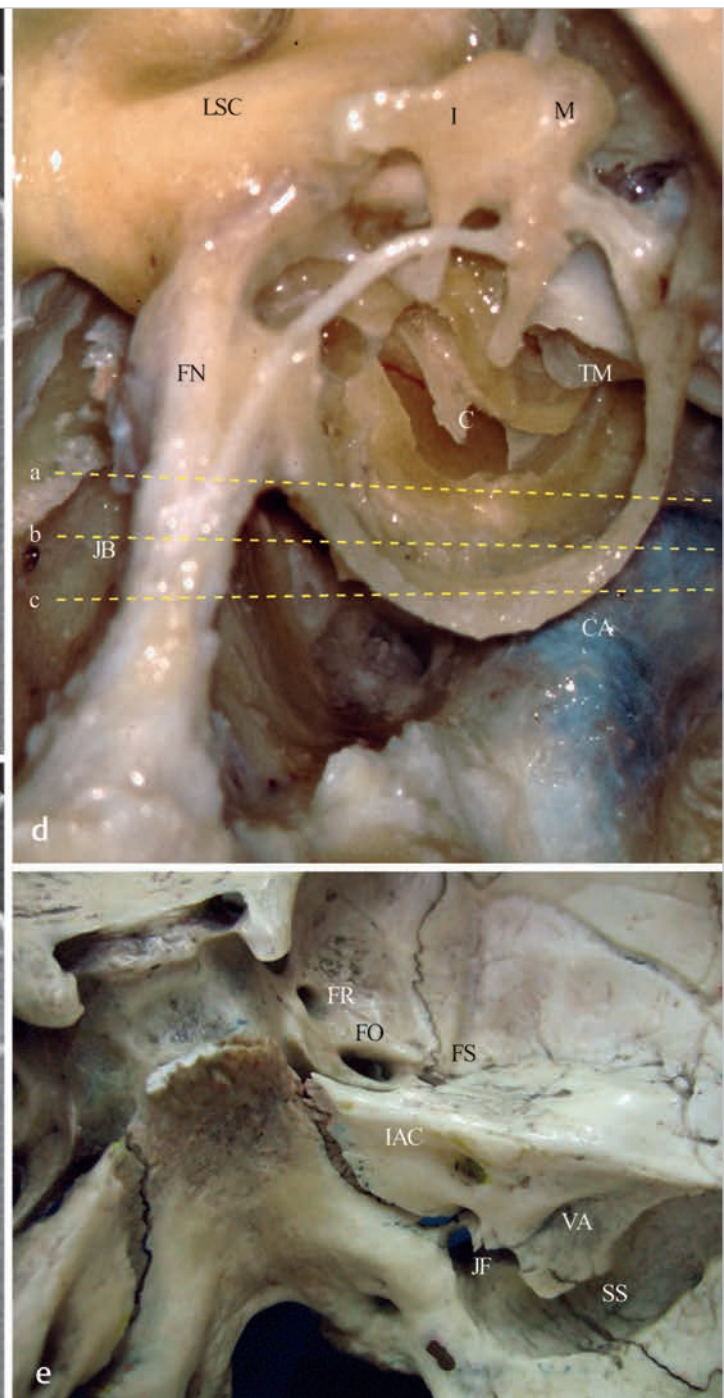
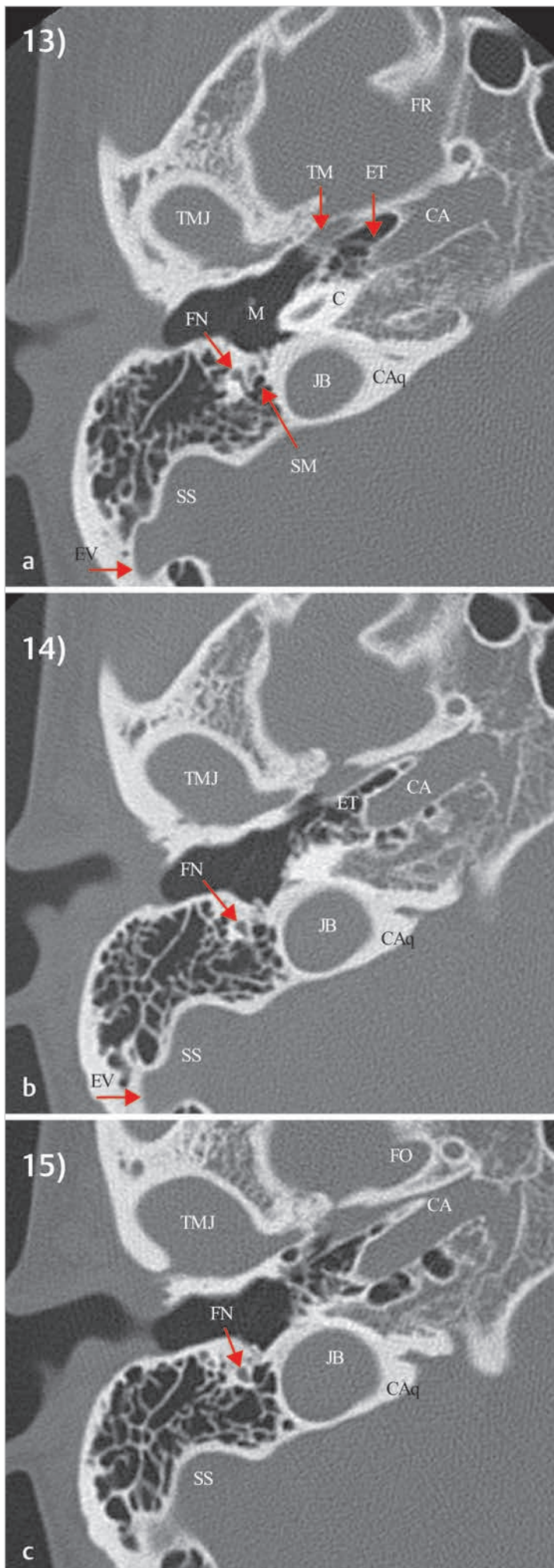


Fig. 1.25 (a–h) C, cochlea; CA, carotid artery; CAq, cochlear aqueduct; ET, eustachian tube; EV, emissary vein; FN, facial nerve; FO, foramen ovale; FR, foramen rotundum; FS, foramen spinosum; I, incus; IAC, internal auditory canal; JB, jugular bulb; JF, jugular foramen; LSC, lateral semicircular canal; M, malleus; SM, stapedial muscle; SS, sigmoid sinus; TM, tensor tympani muscle; TMJ, temporomandibular joint; VA, vestibular aqueduct.

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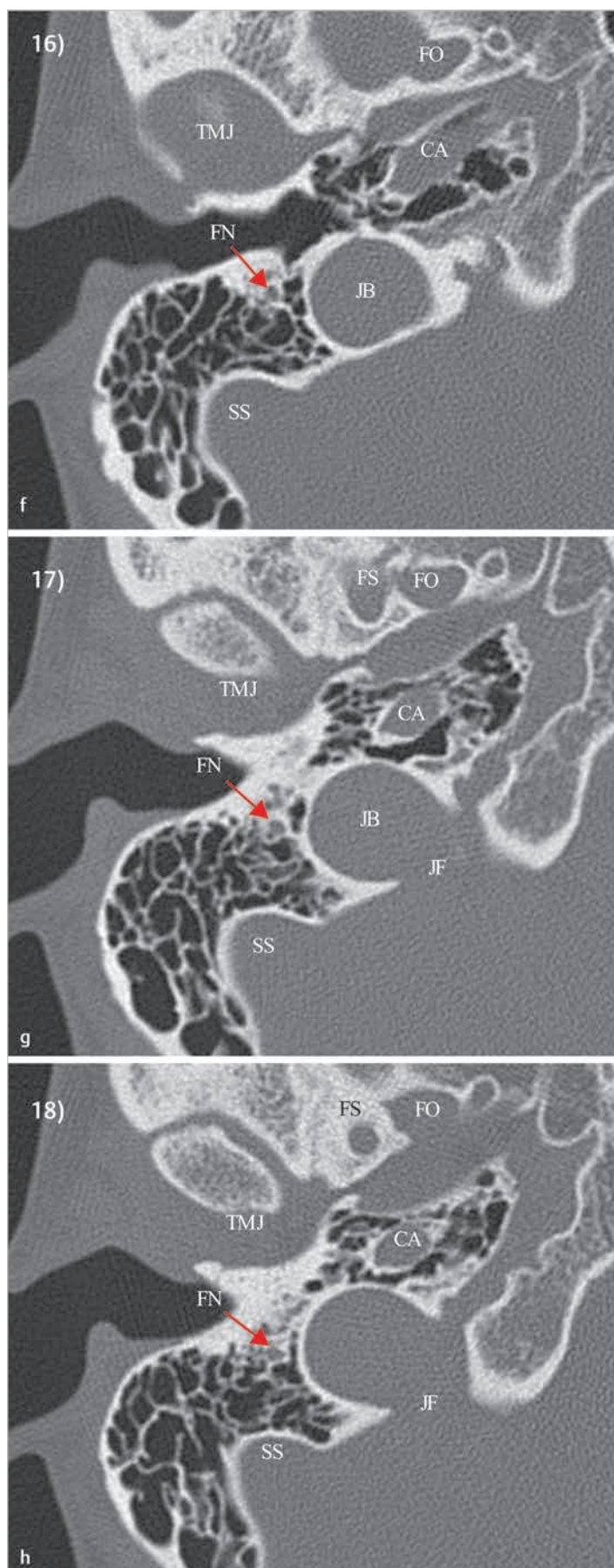


Fig. 1.25 (continued) (a–h) C, cochlea; CA, carotid artery; CAq, cochlear aqueduct; ET, eustachian tube; EV, emissary vein; FN, facial nerve; FO, foramen ovale; FR, foramen rotundum; FS, foramen spinosum; I, incus; IAC, internal auditory canal; JB, jugular bulb; JF, jugular foramen; LSC, lateral semicircular canal; M, malleus; SM, stapedial muscle; SS, sigmoid sinus; TM, tensor tympani muscle; TMJ, temporomandibular joint; VA, vestibular aqueduct.

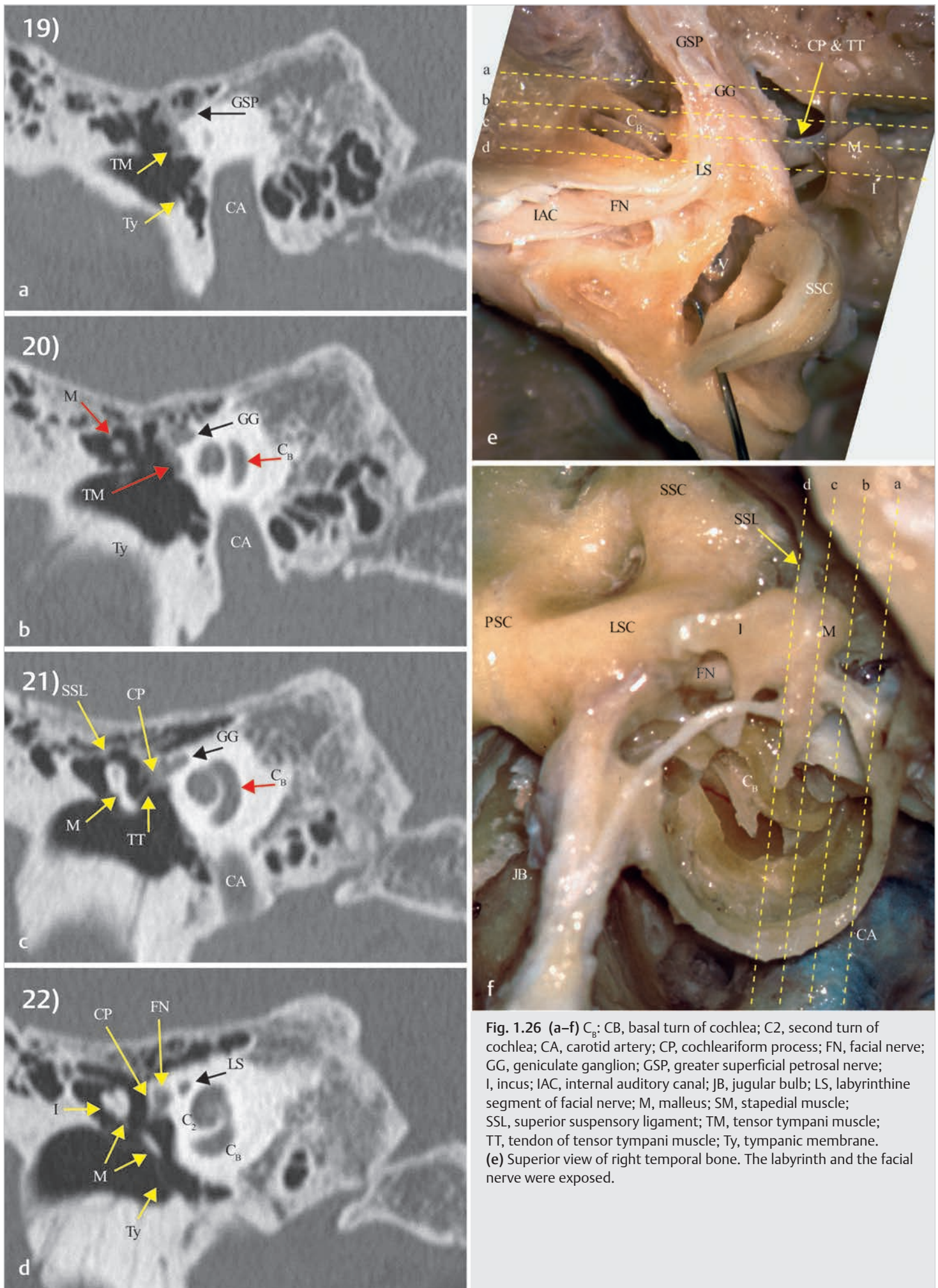


Fig. 1.26 (a–f) C_b: CB, basal turn of cochlea; C₂, second turn of cochlea; CA, carotid artery; CP, cochleariform process; FN, facial nerve; GG, geniculate ganglion; GSP, greater superficial petrosal nerve; I, incus; IAC, internal auditory canal; JB, jugular bulb; LS, labyrinthine segment of facial nerve; M, malleus; SM, stapedial muscle; SSL, superior suspensory ligament; TM, tensor tympani muscle; TT, tendon of tensor tympani muscle; Ty, tympanic membrane. (e) Superior view of right temporal bone. The labyrinth and the facial nerve were exposed.

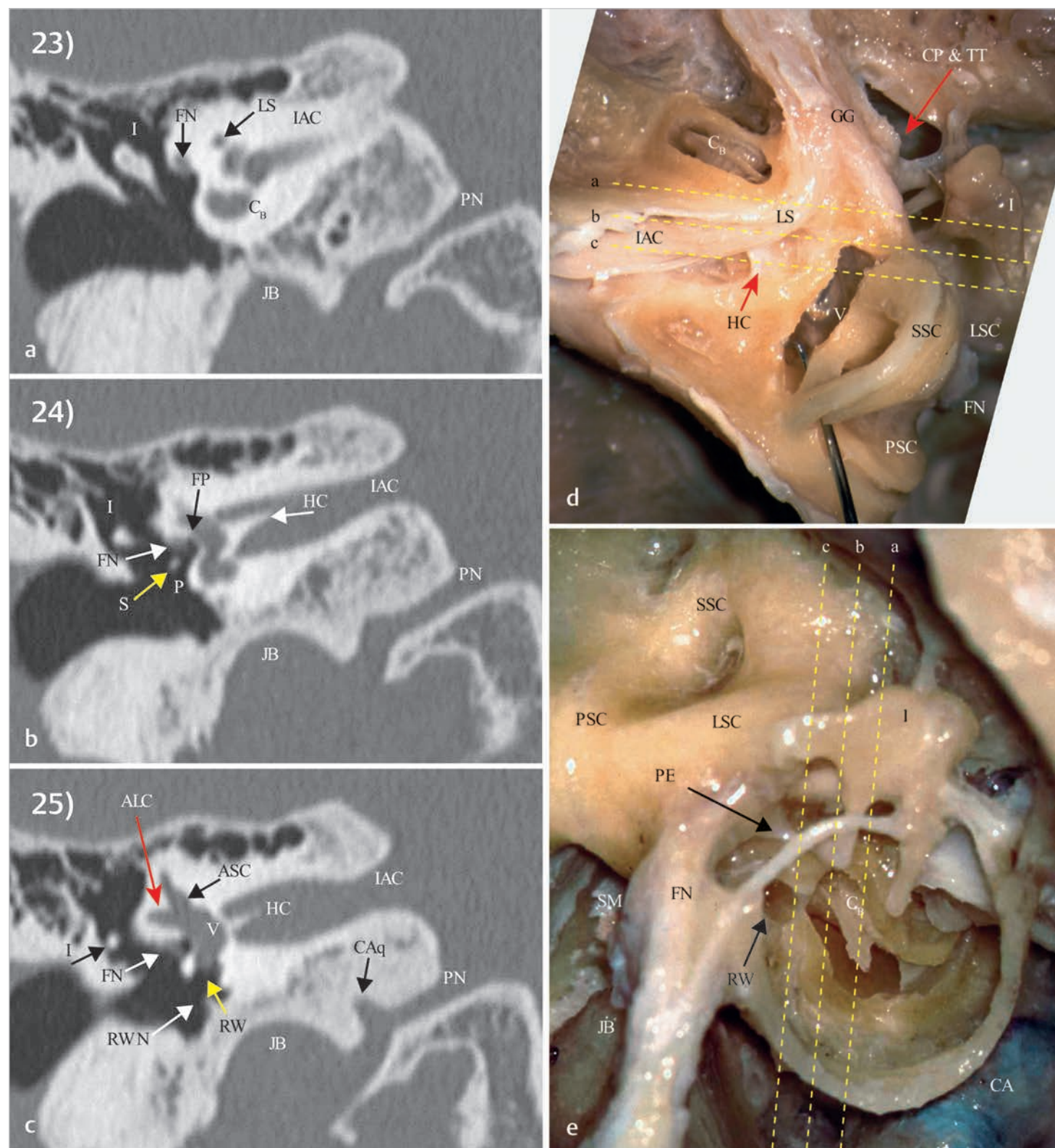


Fig. 1.27 (a–e) ALC, ampulla of lateral semicircular canal; ASC, ampulla of superior semicircular canal; C_b , basal turn of cochlea; CA, carotid artery; CAq, cochlear aqueduct; FN, facial nerve; FP, footplate of stapes; GG, geniculate ganglion; HC, horizontal crest; I, incus; IAC, internal auditory canal; JB, jugular bulb; LSC, lateral semicircular canal; P, promontory; PN, pars nervosa of jugular foramen; PSC, posterior semicircular canal; RW, round window; RWN, round window niche; S, stapes; SM, stapedial muscle; SSC, superior semicircular canal.

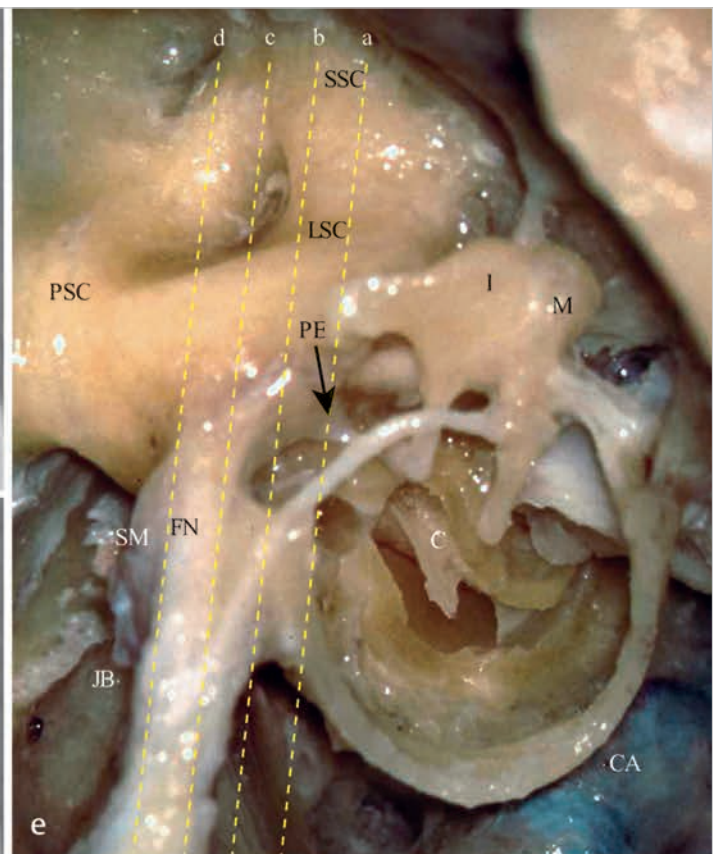
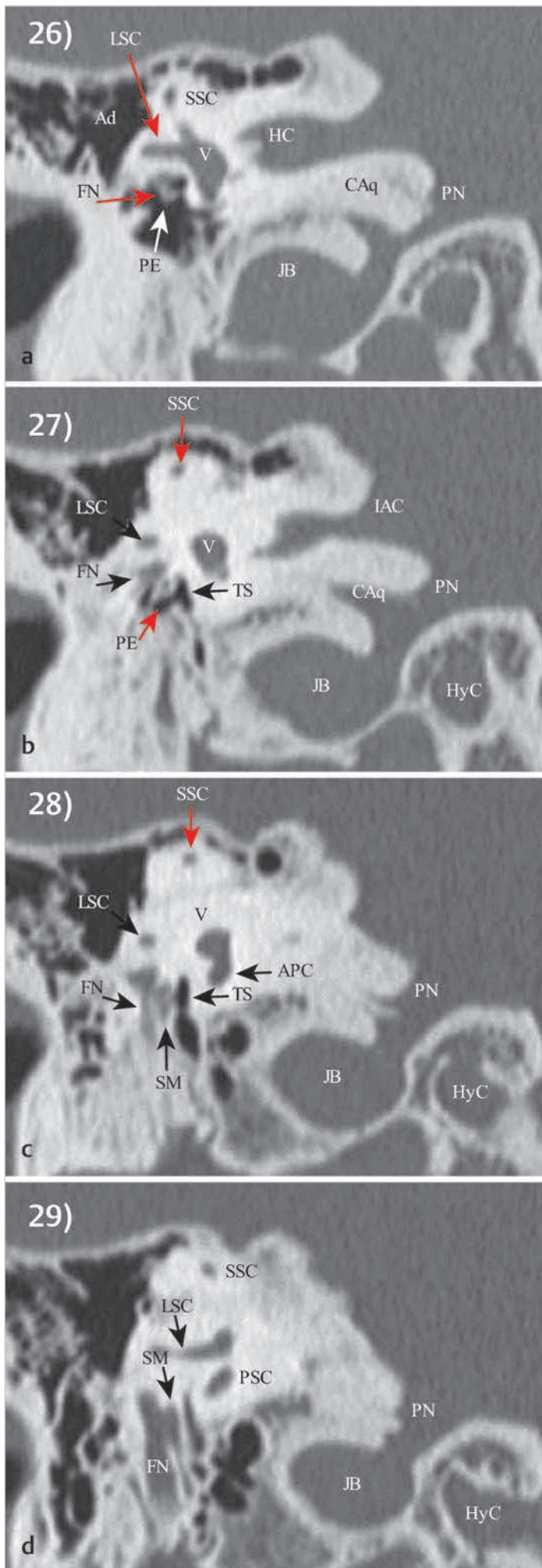


Fig. 1.28 (a–e) Ad, additus ad antrum; APC, ampulla of posterior semicircular canal; ASC, ampulla of superior semicircular canal; C, cochlea; CA, carotid artery; CAq, cochlear aqueduct; FN, facial nerve; HC, horizontal crest; HyC, hypoglossal canal; I, incus; IAC, internal auditory canal; JB, jugular bulb; LSC, lateral semicircular canal; M, malleus; PE, pyramidal eminence; PN, pars nervosa of jugular foramen; PSC, posterior semicircular canal; SSC, superior semicircular canal; SM, stapedial muscle; SSC, superior semicircular canal; TS, tympanic sinus; V, vestibule.

2 Diagnosis of Cholesteatoma

Cholesteatoma is an epidermal inclusion cyst localized in the middle ear, whose capsule and matrix is formed from stratified squamous epithelium. The desquamating debris includes pearly white lamellae of keratin that accumulate concentrically, forming the cholesteatoma mass. The term cholesteatoma is actually a misnomer. It is derived from the Greek words “chole” or bile, “steatos” or fat, and “oma” or tumor. There is no relation between cholesteatoma and bile or fat. The suffix “oma” (tumor), however, is more appropriate because cholesteatoma can be considered an epidermal inclusion cyst forming a tumor in the ear. Fetid otorrhea and hearing loss are the main complaints in most of cholesteatoma patients. In addition, complicated cases can manifest with vertigo and/or facial nerve paralysis. Vertigo occurs as a result of labyrinthine fistula, which is most commonly located in the lateral semicircular canal. Facial paralysis can be caused by pressure of the cholesteatoma sac or neuritis.

The most important finding for diagnosing cholesteatoma is usually obtained in micro-otoscopy in the outpatient clinic. Clue for diagnosis may be scant, such as a very small erosion in the pars flaccida, or small whitish mass behind the tympanic membrane. Therefore, it is essential to carefully check the entire tympanic membrane using either a microscope or an endoscope if patients visit with some otologic complaints. We prefer to use an endoscopy in the outpatient clinic, since it gives a picture of the entire tympanic membrane even if there is a tight curve in the meatus. If presence of cholesteatoma is diagnosed or speculated, radiological examination with high-resolution computed tomography (CT) is indicated. The thickness of each slice should be less than 1 mm to visualize middle ear structures. Even though CT is not able to discriminate cholesteatoma from other soft tissues and effusions, it gives abundant information regarding extension of the disease and bony erosions that serves for surgery. If there is any doubt of meningoencephalic herniation or extension to the petrous apex, magnetic resonance imaging (MRI) is indicated. The MRI gives excellent contrast between cholesteatoma and other soft tissues when proper modality is applied. Since diffusion-weighted modality gives high signal in cholesteatoma, it is also useful for detection of residual lesion after tympanoplasty and subtotal petrosectomy. In cases of petrous bone cholesteatoma, otoscopy may be irrelevant or only demonstrates pars flaccida perforation or an open mastoid cavity with evidence of otorrhea. When a patient presents with hearing

loss (sensorineural or mixed) and/or facial nerve paralysis with or without a retrotympanic mass, the possibility of petrous bone cholesteatoma (PBC) should be considered. The MRI is fundamental to evaluate such cases. Once petrous bone cholesteatoma is identified, it is necessary to perform a high-resolution CT scan of the temporal bone to evaluate extension of the cholesteatoma.

The PBCs are locally aggressive, and may extend to the clivus, nasopharynx, sphenoid sinus, the infratemporal fossa, and intradural compartment.

Regarding the source of the squamous epithelium, cholesteatoma can be classified into two types: acquired and congenital (► Table 2.1); the acquired ones are much more common than the congenital ones, comprising the majority of surgical cases.

In acquired cholesteatoma, the squamous epithelium originates from the skin covering either the tympanic membrane or the external auditory canal. The acquired ones can be divided into two categories: primary and secondary. The primary cholesteatoma is formed from a retraction pocket that becomes so deep that keratin debris can no longer be expelled, leading to its accumulation and subsequent cholesteatoma formation. Cause of such retraction is not known fully, but dysfunction of the eustachian tube related to some infectious condition, such as sinusitis, allergy, and otitis media, seems to play a key role. Such retraction pockets often remain asymptomatic until they become infected, resulting in otorrhea and hearing loss. In some cases, the only symptom might be a progressive hearing loss due to erosion of the ossicular chain. The primary cholesteatomas are subclassified according to its initial localization. The pars flaccida (or epitympanic) type originates from the pars flaccida that seems more susceptible to negative pressure in the middle ear. The pars tensa (or mesotympanic) type is less frequent, originating from the pars tensa of the tympanic membrane, usually the postero-superior quadrant. Since it erodes the incudostapedial joint from the beginning, patients are likely to present with considerable hearing loss. In cholesteatoma of the external auditory canal, destruction of the temporal bone starts from the external auditory canal, and inflamed skin with debris infiltrates the middle ear. Different from the former two types, ischemic condition of the bone is speculated to play a key role. Secondary cholesteatoma is formed by the skin advanced into the middle ear through a disrupted barrier formed by the tympanic membrane and the skin in the external auditory canal. The disruption occurs in a chronic

Table 2.1 Categorization of cholesteatoma PBC

Source of skin	Subclassification	Localization or cause	Termed
Acquired	Primary	Pars flaccida (epitympanic)	
		Pars tensa (mesotympanic)	
		External auditory canal	
	Secondary	Chronic otitis media	
		Iatrogenic	
		Traumatic	
Congenital	Primary or secondary	Medial to labyrinth	PBC
		Middle Ear	(Congenital)

Abbreviation: PBC, petrous bone cholesteatoma.

perforation of the tympanic membrane, that is, chronic otitis media. Marginal perforations and tympanosclerosis increase risk of the skin crossing the border. Medical intervention can tuck the squamous epithelium into the middle ear. Such procedures include myringotomy, insertion of the ventilation tube, and tympanoplasty. The tuck of the skin also occurs in traumatic tympanic membrane perforation and temporal bone fracture.

Congenital cholesteatoma is speculated to be derived from entrapped ectodermal cellular debris during embryonic development. When it involves the middle ear, it appears as a whitish retrotympenic mass that may be localized either anterior or posterior to the malleus. In rare cases, cholesteatoma may arise in some part of the temporal bone away from the tympanic membrane. In such cases, the tympanic membrane seems intact, or the only indication is presence of middle ear effusion. In such cases, the lesion may be recognized in radiological examinations performed after some neurological symptoms appear, or only by chance.

When cholesteatoma involves the petrous part of the temporal bone that is medial to the labyrinth, it is termed petrous bone cholesteatoma. The source of the skin can be either congenital

or acquired, as a consequence of advanced lesion. Because of its localization, the petrous bone cholesteatoma can invade the labyrinth, cochlea, posterior and middle fossa dura, the internal auditory canal, and the petrous apex, and may cause various neurological symptoms and life-threatening conditions.

2.1 Epitympanic Retraction Pocket

It is not always easy to establish a clear distinction between epitympanic or posterosuperior retraction pockets and cholesteatoma (see ►Fig. 2.1 and ►Fig. 2.2). We prefer to follow up these patients with otomicroscopy and endoscopy. A 30-degree endoscope is useful to see clearly the bottom of the retraction. Radiological examination using high-resolution CT may give additional information regarding the safety of the retraction. If the retraction pocket becomes deep, or accumulation of debris starts, a tympanoplasty is indicated. Because of the early stage of the disease, surgery can be done in a single stage.



Fig. 2.1 Right ear. A deep pocket is identified in pars flaccida. Even if the CT scan did not show an apparent cholesteatoma, occasional otorrhea forced the patient to undergo surgery (closed tympanoplasty with attic reconstruction with cartilage and bone paste). No cholesteatoma was found in the mastoid.



Fig. 2.2 Left ear. Deep epitympanic erosion extended to the posterior epitympanum. The neck of the malleus and the body of the incus are under view. The chorda tympani is also evident. The patient did not suffer from otorrhea or hearing loss, but a strict follow-up should be assessed to avoid further development of a cholesteatoma.

2.2 Epitympanic Cholesteatoma

The epitympanic cholesteatoma is the most frequent form of acquired cholesteatoma. The cholesteatoma arises from an epitympanic retraction pocket as described above, and usually does not cause any symptom until it gets infected, interrupts the ossicular chain, erodes the labyrinth, or injure the facial nerve (see ► Fig. 2.3, ► Fig. 2.4, ► Fig. 2.5, ► Fig. 2.6, ► Fig. 2.7, ► Fig. 2.8, ► Fig. 2.9, ► Fig. 2.10, ► Fig. 2.11, ► Fig. 2.12, ► Fig. 2.13, ► Fig. 2.14, ► Fig. 2.15, ► Fig. 2.16, ► Fig. 2.17, ► Fig. 2.18). Most of them can be diagnosed by careful otoscopic inspection. Therefore, it is definitely prohibited to say “OK” to the patient who is complaining ear problems after seeing only the easy-to-access pars tensa. In very rare cases, the orifice of cholesteatoma can be obscured with a re-epithelized granulation tissue covering the pars flaccida. Since only radiological examinations give definitive clue, high grade of suspicion with knowledge is required to diagnose such cases.

In some cases, invagination of the skin in the pars flaccida and the pars tensa coexist, or extend to each other making categorization of primary cholesteatoma into two not possible. The situation can be called epimesotympanic cholesteatoma.



Fig. 2.3 Left ear. Epitympanic cholesteatoma in a 20-year-old man in the only hearing ear. The whitish cholesteatoma mass is visible anterior to the malleus (arrow). This is an example on how an epitympanic pocket can progressively led to a cholesteatoma. This patient has undergone removal of a right petrous bone massive cholesteatoma (for definition and classification see Chapter 10) through a transotic approach 5 years before. The left epitympanic retraction pocket (see ► Fig. 8.9) was followed up until the evidence of a cholesteatoma. The patient did not complain of any symptom on the left ear and hearing function was normal. Considering the small size of the cholesteatoma, a left closed tympanoplasty was performed with preservation of the whole ossicular chain (see ► Fig. 8.12, ► Fig. 8.13, ► Fig. 8.14, ► Fig. 8.15, ► Fig. 8.16). A detailed description of the steps of open and closed tympanoplasties will be provided at the end of the chapter.

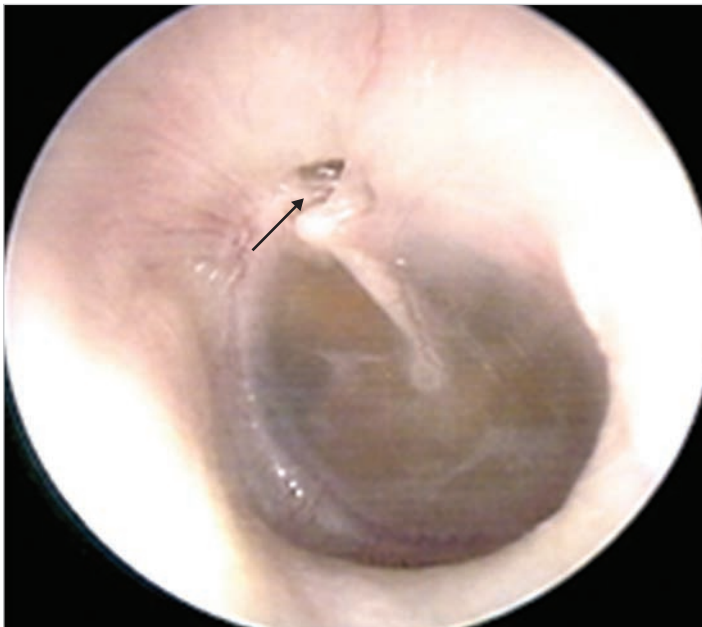


Fig. 2.4 Same case. Otoscopy performed 1 year before that in ► Fig. 2.3. A small controllable anteromalleolar epitympanic retraction pocket is visible (arrow). Considering that it is the only hearing ear surgery is questionable at this stage, but a strict follow-up is mandatory because early detection of a cholesteatoma is crucial for a correct management and outcome.

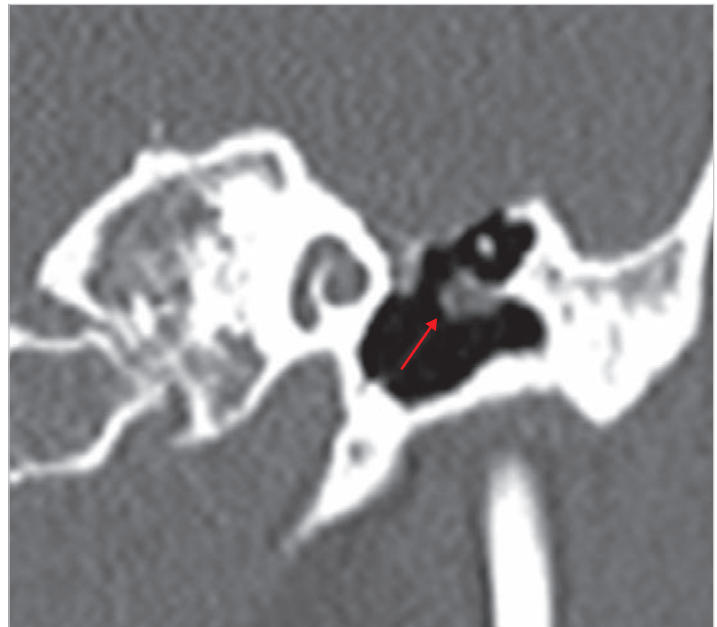


Fig. 2.5 CT scan of the same case, coronal view. A small epitympanic cholesteatoma is visible (arrow).



Fig. 2.6 Left ear. Epitympanic cholesteatoma. The head of the malleus and the body of the incus are visible. The inferior and posterior quadrants of the tympanic membrane are tympanosclerotic. The cholesteatoma was lateral to the ossicular chain (see ► Fig. 2.10). Hearing function was normal. A modified Bondy technique open tympanoplasty was performed and no recurrence of cholesteatoma occurred during the follow-up.

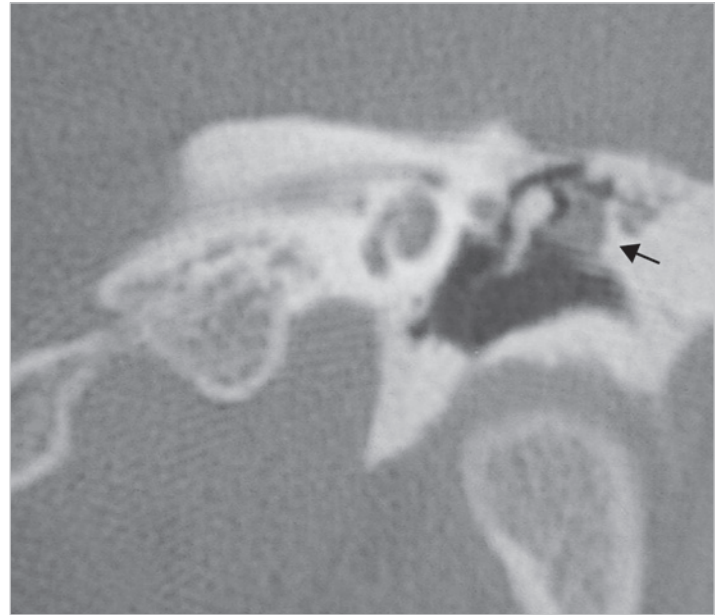


Fig. 2.7 CT of the same case, coronal view. The cholesteatoma is limited in the epitympanic area (arrow), lateral to the head of the malleus. The mesotympanum is free of disease. The case can be a complete indication of modified Bondy technique.

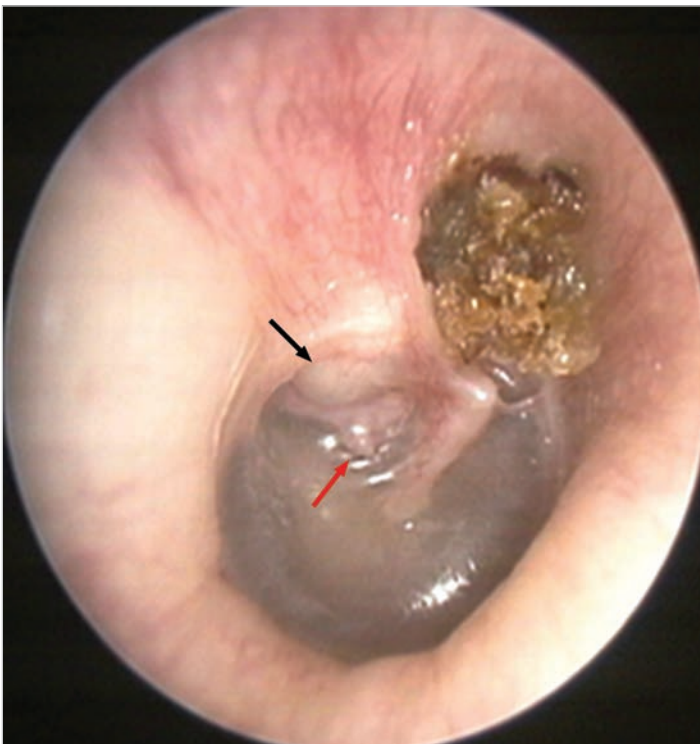


Fig. 2.8 Epitympanic cholesteatoma with erosion of the head of the malleus and the incus. The cholesteatoma descends to the tympanic cavity (black arrow) to contact with the stapes. The head of the stapes is adherent to the tympanic membrane (red arrow: myringostapediopexy) resulting in normal hearing. The rest of the tympanic membrane is slightly retracted due to obstruction of the eustachian tube. Possibility of postoperative hearing deterioration has to be informed preoperatively.



Fig. 2.9 Large epitympanic erosion with cholesteatoma. Audiometry showed moderate conductive hearing loss.

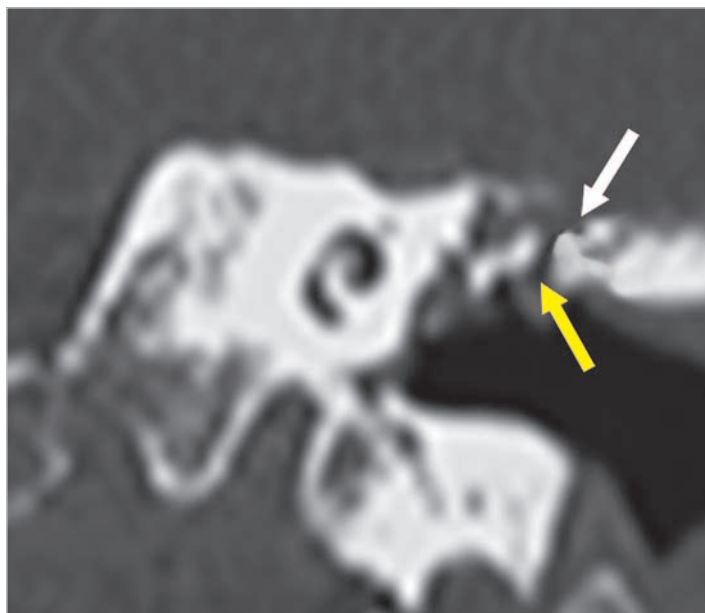


Fig. 2.10 CT scan of the same case, coronal view. Epitympanic cholesteatoma with erosion of the head of the malleus (yellow arrow) and thinning of the tegmen tympani (white arrow).

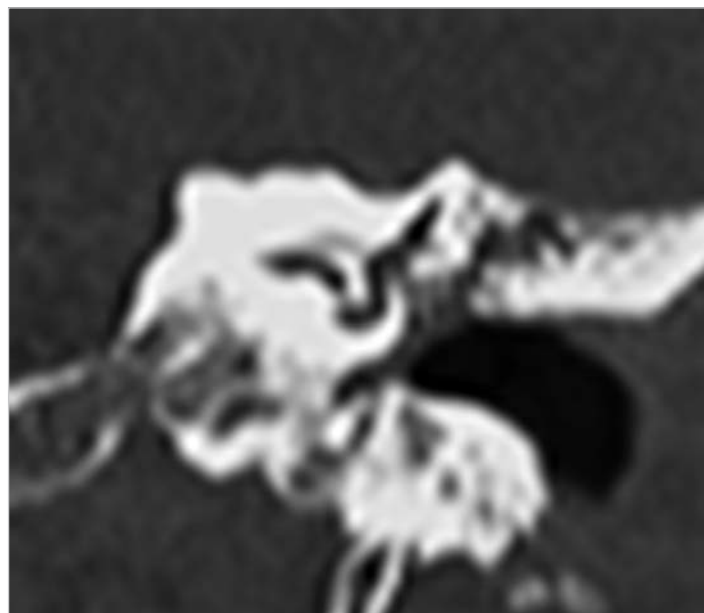


Fig. 2.11 CT scan of the same case, coronal view. The long process of the incus and stapes superstructure are eroded by the cholesteatoma.

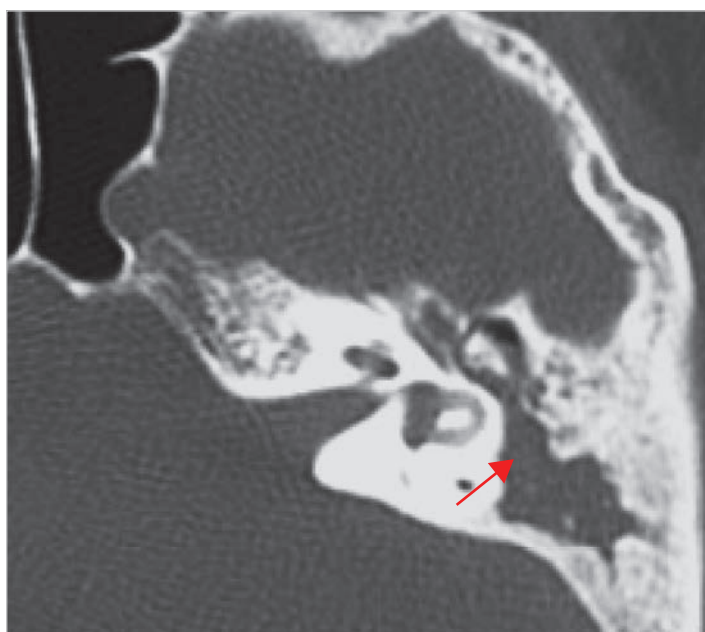


Fig. 2.12 CT scan of the same case, axial view. The cholesteatoma extends posteriorly toward the antrum and the mastoid (arrow). However, some of the opacification may be effusion and scar tissue. Incapability to discriminate soft tissue is one of the drawbacks of CT examination.



Fig. 2.13 Another case of epitympanic cholesteatoma. A deep erosion with debris involving the head of the malleus and the body of the incus is present in the attic.

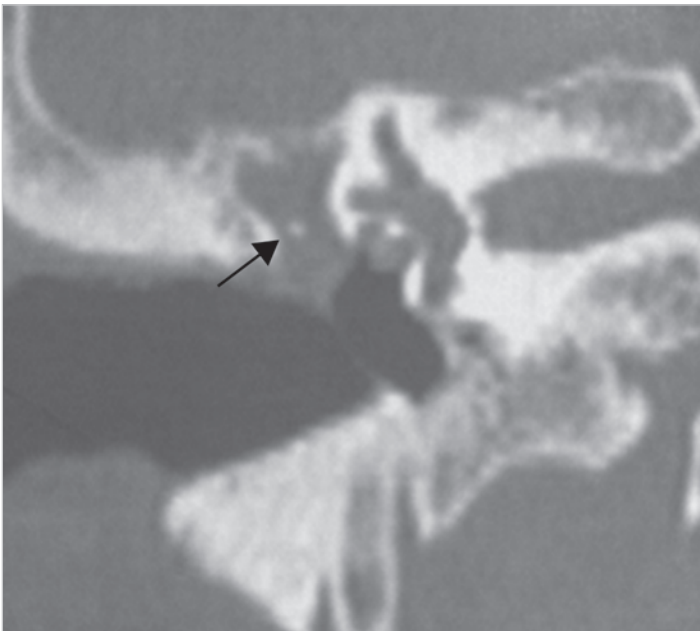


Fig. 2.14 CT scan of the same case, coronal view. Epitympanic cholesteatoma severely erodes the short process of the incus.



Fig. 2.15 Left ear of the same patient. Cholesteatoma with marked erosion of the scutum and epidermization of the attic and mesotympanum. The cholesteatoma debris was partially cleaned. The residual pars tensa shows tympanosclerosis. Intraoperatively, the ossicular chain was absent. The otoscopic view of the left ear is apparently more advanced than the right ear. This, however, was not the case intraoperatively since the marked epitympanic erosion shown here allowed self-cleaning of the cholesteatoma debris (see CT scan, ► Fig. 2.16). Because of the total destruction of the ossicular chain, a second stage was programmed for functional reconstruction.



Fig. 2.16 CT of the same case showing cholesteatoma extension in the mastoid in the right ear and self-cleaning of the cholesteatoma debris in the left ear (arrows).

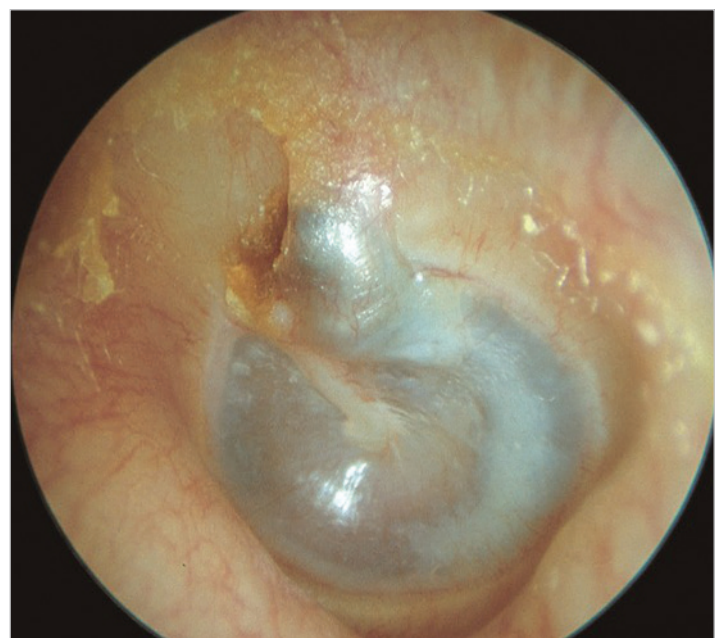


Fig. 2.17 Left ear. Cystic retrotympenic cholesteatoma situated posterior to the malleus. The tympanic membrane shows bulging at the level of the pars flaccida and slight retraction with tympanosclerosis in the posterior quadrants. Since debris is covered, inattentive observation may overlook presence of cholesteatoma.

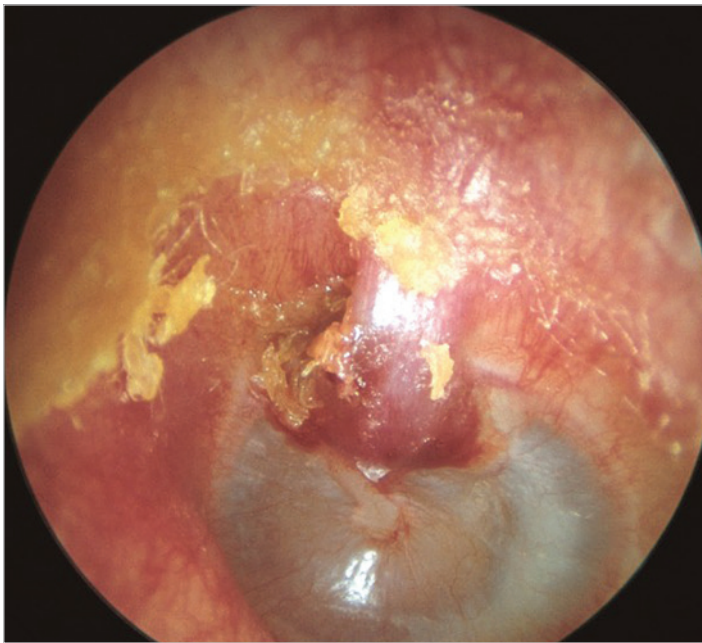


Fig. 2.18 Same case as in ► Fig. 2.17 during an acute inflammatory episode. Note the increase in size of the cholesteatoma.

2.3 Mesotympanic and Epimesotympanic Cholesteatoma

Mesotympanic cholesteatoma may arise from a retraction pocket in the pars tensa, or a perforation in the tympanic membrane. (See ► Fig. 2.19, ► Fig. 2.20, ► Fig. 2.21, ► Fig. 2.22, ► Fig. 2.23, ► Fig. 2.24, ► Fig. 2.25, ► Fig. 2.26, ► Fig. 2.27, ► Fig. 2.28.) Progression of a posterior mesotympanic retraction pocket is often associated with erosion of the ossicular chain. The retraction easily covers the lateral semicircular canal to make a labyrinthine fistula. In limited cases of cholesteatoma in early stage, one stage surgery may be possible using thick cartilage as a columella, and simultaneously as a reinforcement of the posterosuperior quadrant. In advanced cases, the surgery should be staged. When an extensive erosion of the posterior wall is present, a modified radical mastoidectomy is indicated in the elderly, whereas a staged open tympanoplasty is performed in younger patients. The same strategy is also followed in patients presenting with bilateral cholesteatoma.

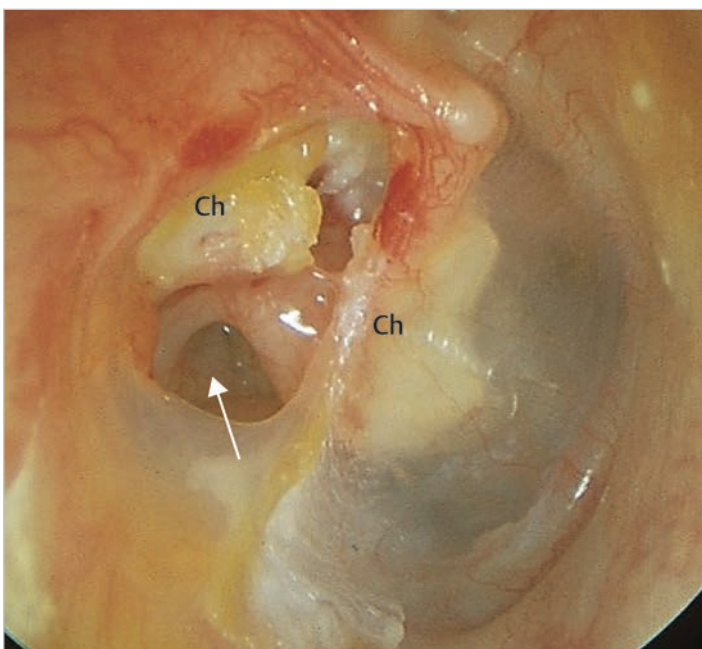


Fig. 2.19 Right ear. A case of secondary cholesteatoma formed medially to the posterior perforation. The cholesteatoma covers the region of the oval window extending toward the attic and progresses anteriorly to cover the medial face of the handle of the malleus. The promontory and the round window (*arrow*) are visible through the perforation. Ch, cholesteatoma.

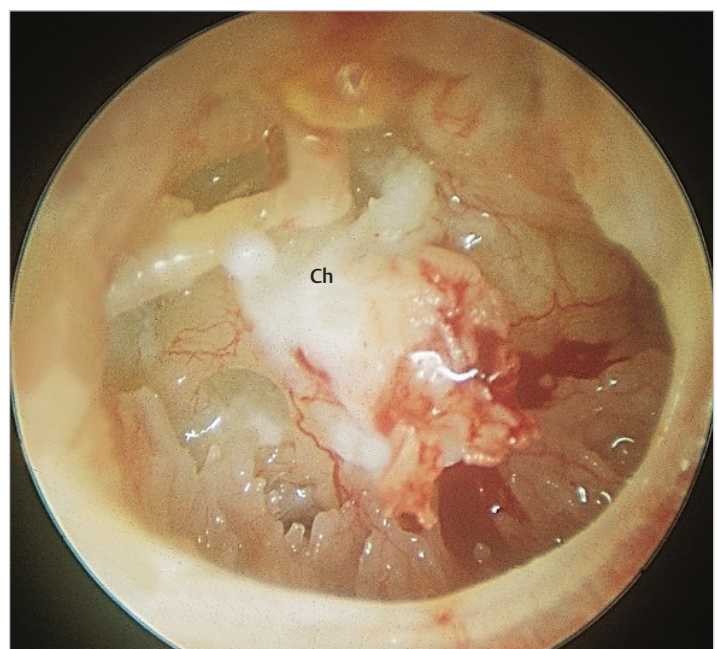


Fig. 2.20 Right ear. A case of secondary cholesteatoma with a total perforation. The handle of the malleus is absent. The long process of the incus and part of the stapes are covered by cholesteatoma, which also involves the promontory. The round window, hypotympanic air cells, and tubal orifice are free from the pathology. Ch, cholesteatoma.

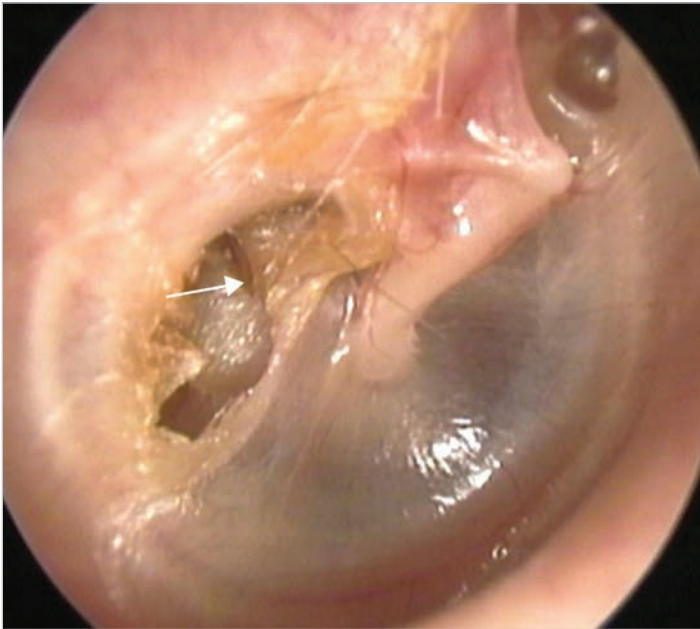


Fig. 2.21 Right ear with a deep mesotympanic retraction pocket with cholesteatoma. An epitympanic retraction is also visible. The incudostapedial joint (*arrow*) and the promontory are completely epithelialized.

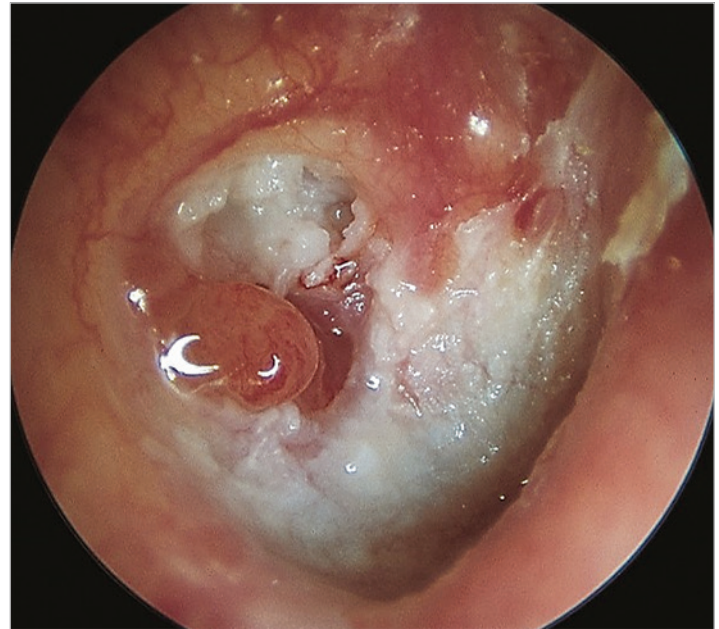


Fig. 2.22 Right ear. Posterior mesotympanic cholesteatoma associated with a polyp are seen at the level of the oval window.



Fig. 2.23 Left ear with mesotympanic cholesteatoma. The area of the incudostapedial joint is completely occupied by cholesteatoma.

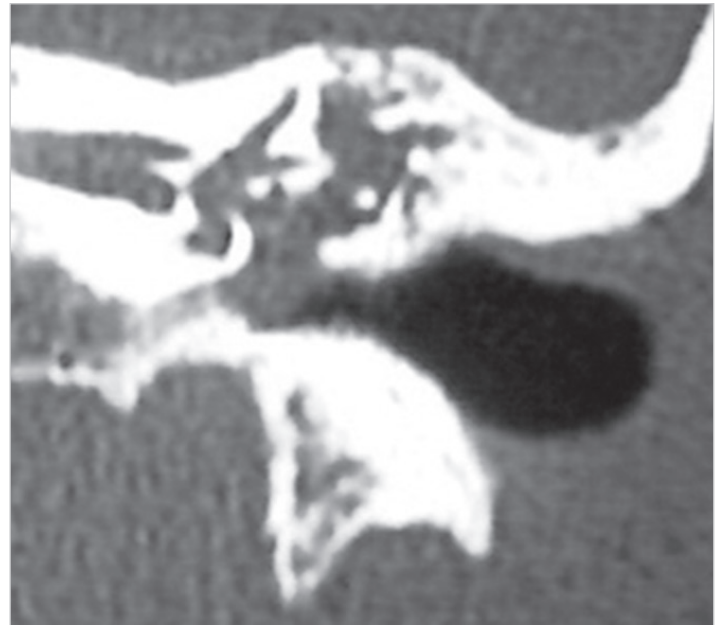


Fig. 2.24 CT scan, coronal view, of the same case. Cholesteatoma fills the middle ear cleft with erosion of the long process of the incus and the suprastructure of the stapes.

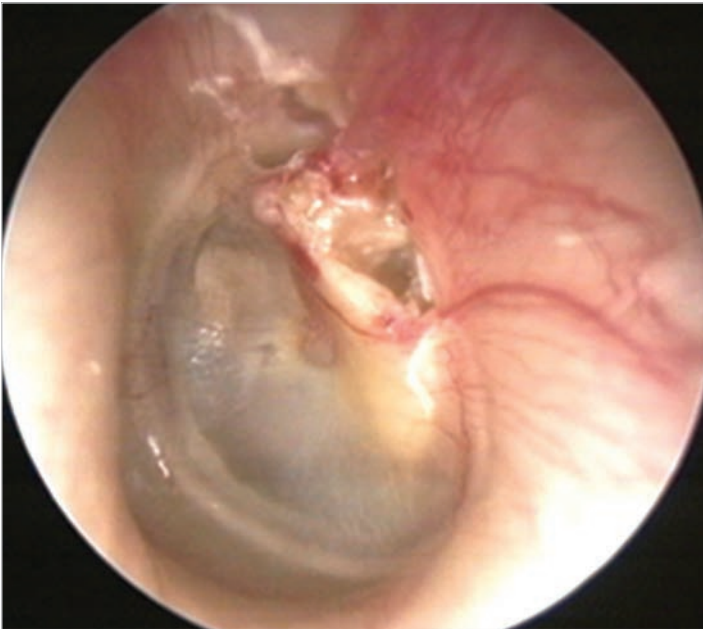


Fig. 2.25 Epimesotympanic cholesteatoma. Even in this case, the long process of the incus is eroded by the pathology. The tympanic membrane shows tympanosclerosis.

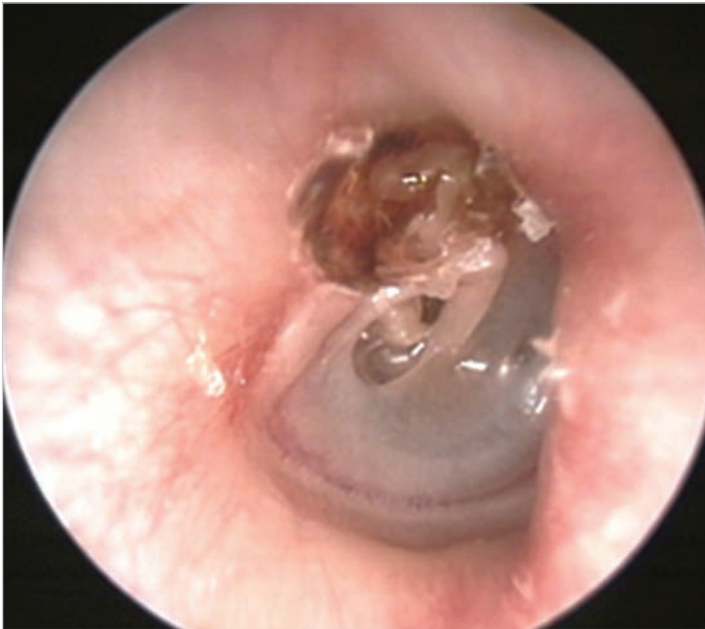


Fig. 2.26 Right ear. Epimesotympanic cholesteatoma. There is a deep epitympanic erosion and a mesotympanic retraction pocket. The incudostapedial joint seems not disrupted, resulting in mild conductive hearing loss. However, in this case the involvement of the whole epitympanic area and the mastoid compartment led to a staged canal wall down (open) tympanoplasty.



Fig. 2.27 CT scan of the same case, coronal view. The head of the malleus is eroded and engulfed by the disease (arrow).



Fig. 2.28 CT scan of the same case, coronal view. The incudostapedial joint is not disrupted (arrow).

2.4 Cholesteatoma Associated with Atelectasis

Acquired cholesteatoma, especially mesotympanic, is frequently associated with atelectasis in the tympanic cavity. In all cases of spontaneous myringostapediopexy with normal preoperative hearing or elderly patients with normal contralateral hearing, we

prefer to leave the atelectatic tympanic membrane untouched after verifying the absence of any middle ear cholesteatoma. In severe cases, healthy mucosa in the tympanic cavity is missing in severe cases, staging surgery is indicated. A tympanostomy tube may be required in some cases to prevent readhesion. Refer to ► Fig. 2.29, ► Fig. 2.30, ► Fig. 2.31.

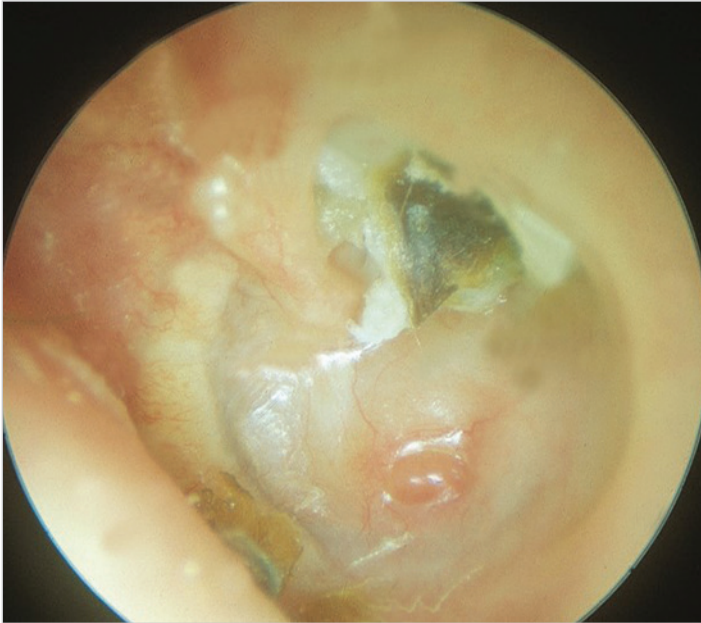


Fig. 2.29 Left ear. Grade IV tympanic membrane atelectasis with posterosuperior mesotympanic retraction forming cholesteatoma. The middle ear mucosa is visible because of absence of the epithelial layer.



Fig. 2.30 Left ear. Epitympanic erosion through which a cholesteatoma is seen filling the attic and causing erosion of the head of the malleus. A grade IV atelectasis of the pars tensa is seen, with formation of polypoidal granulation tissue in the middle ear. In the region posterior to the malleus, the cholesteatoma engulfs the ossicular chain.

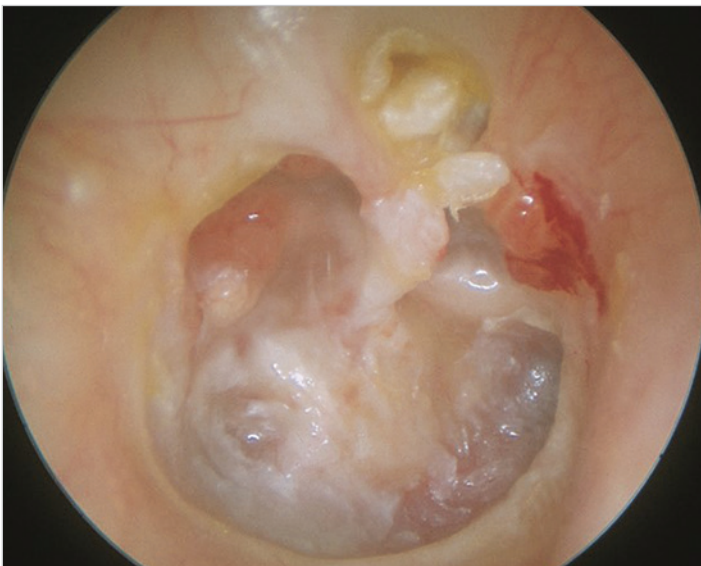


Fig. 2.31 Right ear. Epitympanic cholesteatoma associated with complete atelectasis of the tympanic membrane. This 45-year-old woman underwent a modified radical mastoidectomy, and the tympanic cavity is left untouched.

2.5 Cholesteatoma Associated with Complications

At present, with the diagnostic methods at hand and increased medical care, it is rare to find a cholesteatoma with intracranial complications (e.g., meningitis, brain abscess, lateral sinus thrombophlebitis, etc.). However, cases of cholesteatoma with massive bone destruction, labyrinthine fistulas, severe sensorineural hearing loss resulting in deaf ear, and facial nerve paralysis

are not infrequently encountered. In general, it is not necessary to order a CT scan to diagnose a cholesteatoma. However, in the presence of headache, vertigo, facial nerve paralysis, severe sensorineural hearing loss, or sudden deafness, a high-resolution CT scan of the temporal bone becomes highly important. When intracranial complications are suspected, contrast injection and MRI are also needed. Refer to ► Fig. 2.32, ► Fig. 2.33, ► Fig. 2.34, ► Fig. 2.35, ► Fig. 2.36, ► Fig. 2.37, ► Fig. 2.38, ► Fig. 2.39, ► Fig. 2.40, ► Fig. 2.41.

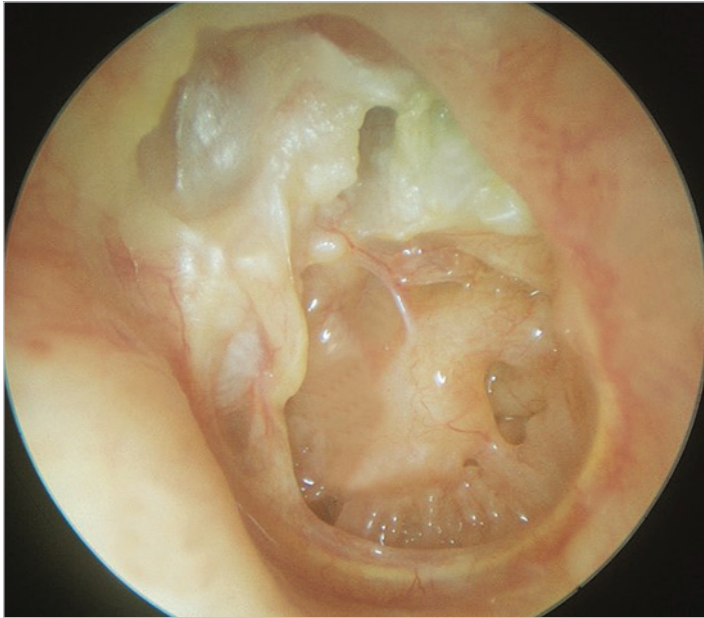


Fig. 2.32 Left ear. Large epitympanic with pars tensa perforation. Cholesteatomatous squamulae are present in the attic and mesotympanic area. The handle of the malleus is present. The tympanic annulus is intact. A preoperative CT scan (► Fig. 8.59) showed the suspicion of a fistula of the lateral semicircular canal, which was encountered during surgery (► Fig. 8.60). In such cases, because of the presence of marked epitympanic erosion and of the fistula, an open tympanoplasty is indicated.

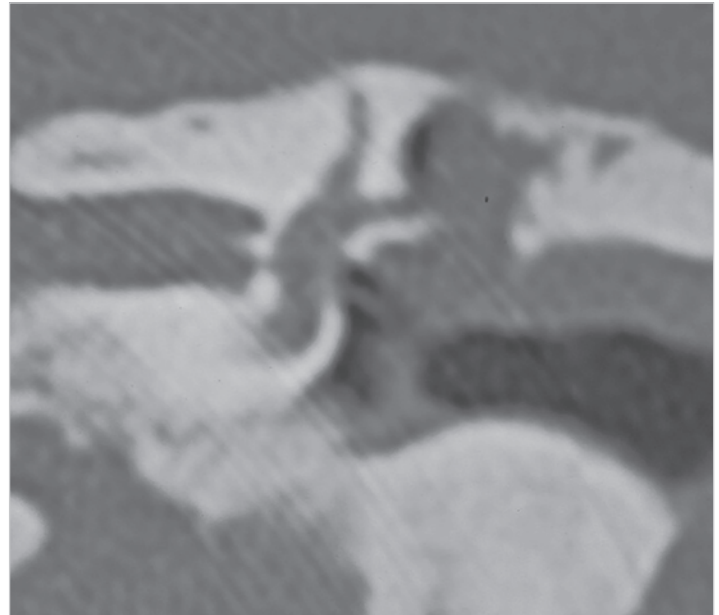


Fig. 2.33 CT scan, coronal view, of the same case. The CT scan, performed 3 months before surgery, showed middle ear pathology compatible with cholesteatoma and suspected fistula of the lateral semicircular canal. The ear was discharging and the patient referred vertigo, while inner ear function was preserved.



Fig. 2.34 Right ear. Bulging of the whole epitympanic area suspected for epitympanic cholesteatoma with meningoencephalic herniation. The CT scan (► Fig. 2.35) showed a large bony defect of the tegmen with soft tissue in the middle ear. Intraoperatively, meningoencephalic herniation surrounded by cholesteatoma was found in the middle ear and mastoid.

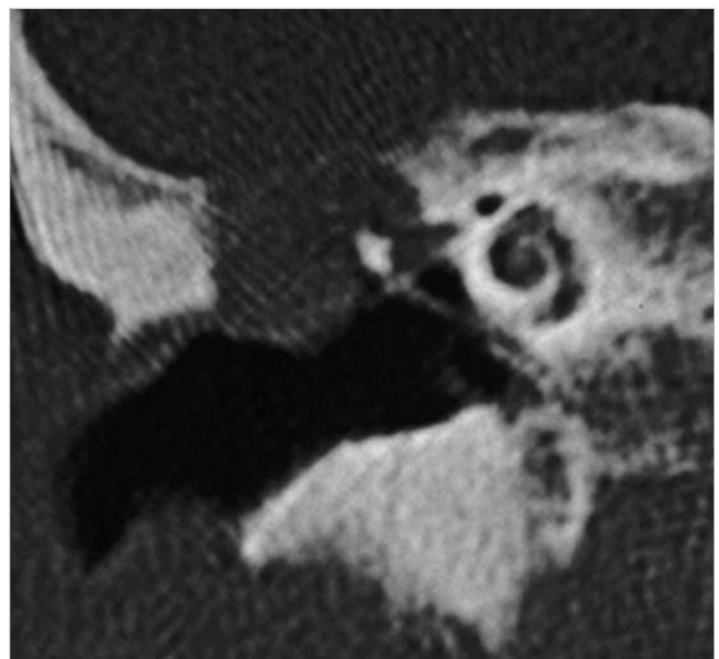


Fig. 2.35 CT scan, coronal view, of the same case. Large bony defect of the tegmen tympani with soft tissue protruding into the middle ear.



Fig. 2.36 Left ear. Large polyp obstructing the external auditory canal. The patient complained of fetid otorrhea, hearing loss, and vertigo. A high-resolution CT scan of the temporal bone was ordered (► Fig. 8.68). A CT scan of the temporal bone should always be ordered in patients with chronic suppurative otitis media suffering from vertigo and/or instability.

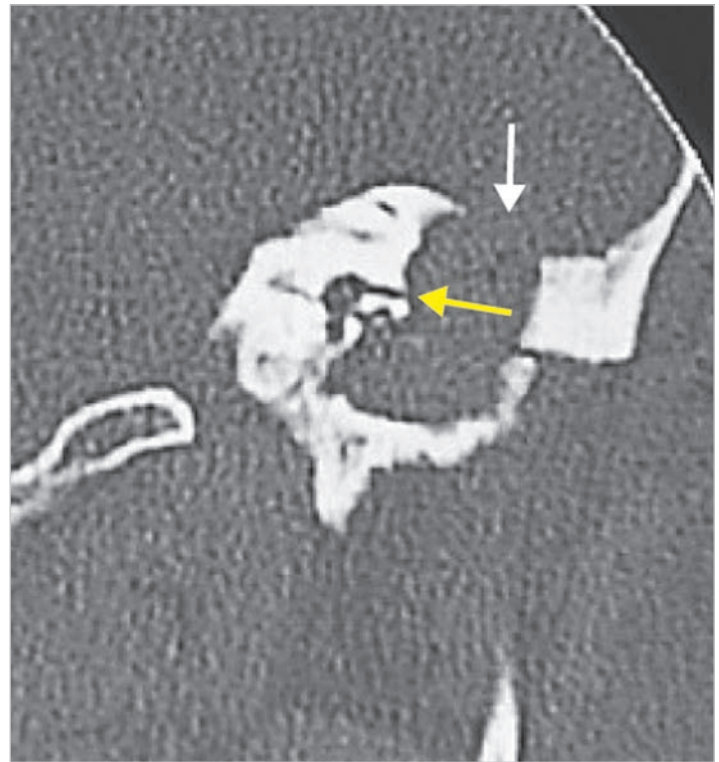


Fig. 2.37 CT scan of the previous case. A huge cholesteatoma causing a fistula of the lateral semicircular canal (yellow arrow) and erosion of the tegmen can be seen (white arrow).

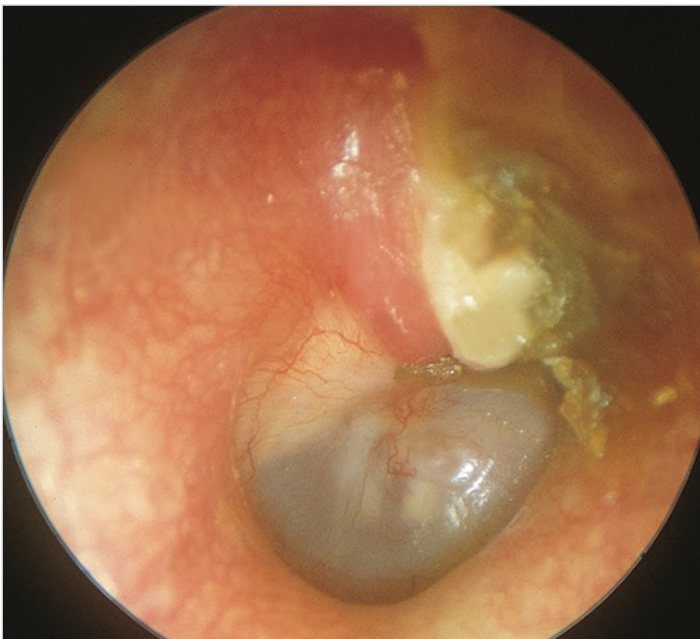


Fig. 2.38 Right ear. Epi- and mesotympanic cholesteatoma. The cholesteatoma debris protruded through the epitympanic erosion. In the posterosuperior quadrant, the cholesteatoma sac can be seen in transparency, causing bulging of the tympanic membrane. The skin surrounding the attic erosion is hyperemic. The pars tensa is intact. The patient complained of frequent episodes of vertigo. A CT scan (see ► Fig. 8.70) demonstrated the presence of a fistula of the lateral semicircular canal.



Fig. 2.39 CT scan of the previous case. The interruption of the lateral semicircular canal caused by the cholesteatoma is apparent (arrow).



Fig. 2.40 Left ear. Small epitympanic retraction pocket in a patient presenting with hearing loss, tinnitus, and recurrent episodes of otitis media with effusion. The contralateral ear had been operated on elsewhere using an open tympanoplasty that resulted in total hearing loss and facial nerve paralysis. A CT scan of the temporal bone revealed the presence of an epitympanic cholesteatoma that caused a fistula of the superior and erosion of the tegmen (see ► Fig. 8.72). The patient underwent open tympanoplasty. Being the only hearing ear, the cholesteatoma matrix was left over the fistula, whereas the tegmental erosion was repaired using cartilage to avoid a meningoencephalic herniation (see Chapter 12).



Fig. 2.41 CT scan of the previous case. Cholesteatoma caused a fistula of the superior semicircular canal (*black arrow*) and erosion of the tegmen (*white arrow*).

2.6 Congenital Cholesteatoma of the Middle Ear

Congenital cholesteatoma of the middle ear is an infrequent pathology during infancy and childhood. It presents behind an intact tympanic membrane, either anterior or posterior to the handle of the malleus. Refer to ► Fig. 2.42, ► Fig. 2.43, ► Fig. 2.44, ► Fig. 2.45, ► Fig. 2.46, ► Fig. 2.47, ► Fig. 2.48, ► Fig. 2.49, ► Fig. 2.50, ► Fig. 2.51, ► Fig. 2.52, ► Fig. 2.53, ► Fig. 2.54, ► Fig. 2.55, ► Fig. 2.56, ► Fig. 2.57, ► Fig. 2.58, ► Fig. 2.59.

Anterosuperior cholesteatoma can be removed through an extended tympanotomy that permits the preservation of the tympanic membrane and ossicular chain integrity. Posterior cholesteatoma, however, requires a staged closed tympanoplasty. The second stage serves to check for any residual cholesteatoma. The ossicular chain, which is generally eroded in the posterior type, can be reconstructed at this stage.

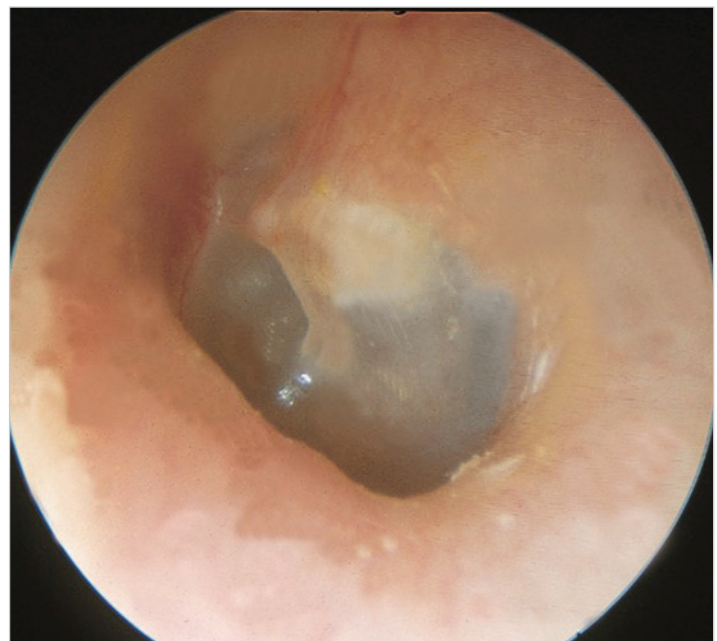


Fig. 2.42 Left ear. Congenital cholesteatoma (type A2, see Chapter 8) seen as a white retrotympenic mass causing bulging of the posterosuperior quadrant of the tympanic membrane. Neither drum perforation nor bony erosion is detected. In this case, the cholesteatoma caused erosion of the long process of the incus with resultant conductive hearing loss.

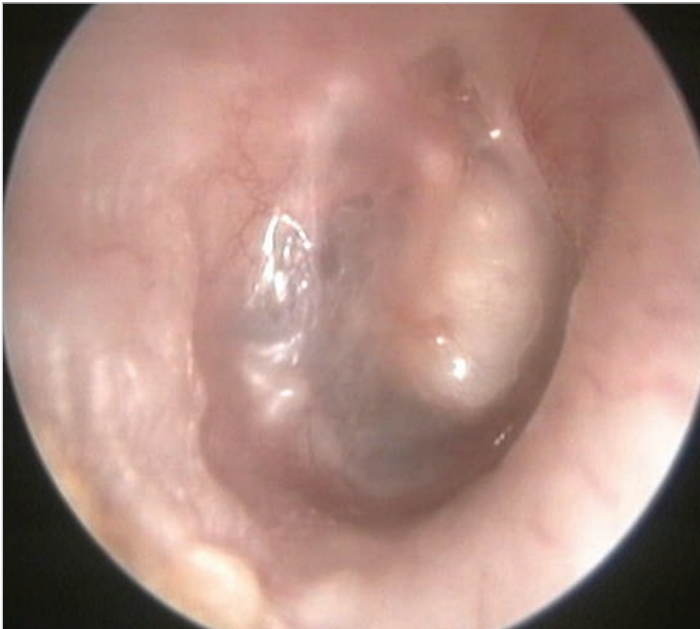


Fig. 2.43 Right ear. Type A1 congenital cholesteatoma (see Chapter 8). The cholesteatoma is located in the perimalleolar area. The tympanic membrane is slightly retracted, and audiometry showed mild conductive hearing loss.

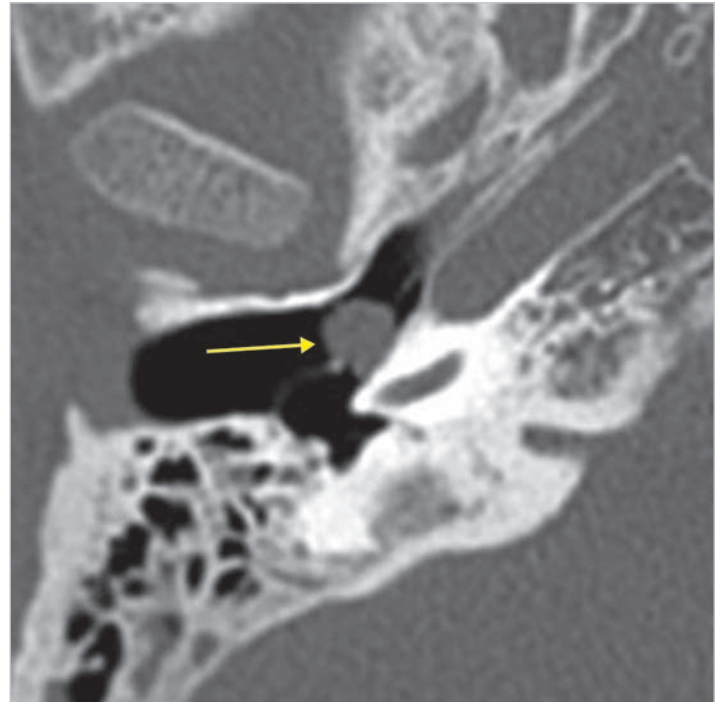


Fig. 2.44 CT scan of the right ear of the same patient, axial view. The cholesteatoma is in contact with the promontorium (arrow).

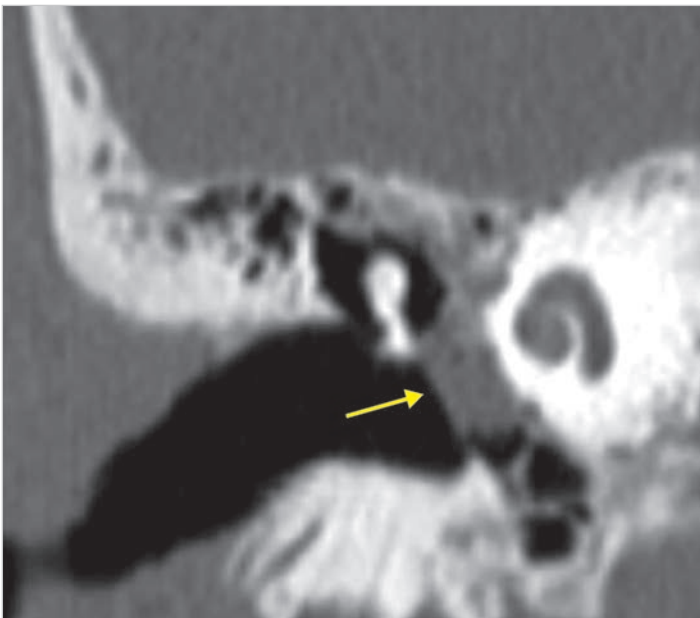


Fig. 2.45 CT scan of the right ear of the same patient, coronal view. The cholesteatoma pearl is clearly visible medial to the malleus (arrow).



Fig. 2.46 Congenital cholesteatoma in an 18-year-old female patient with the onset of right hearing loss since the last 2 months. No history of chronic otitis was reported. A white mass is clearly visible in the mesotympanic area. A CT scan showed the presence of a cholesteatoma involving both the epitympanic and the mesotympanic areas (type A/B: see Chapter 8). Audiometry showed moderate right conductive hearing loss (see ► Fig. 9.10).

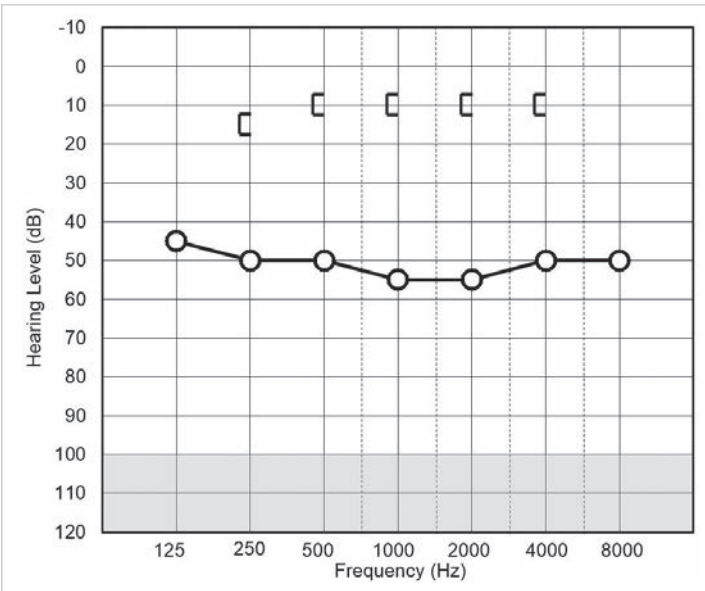


Fig. 2.47 Audiometry of the previous case showing right conductive hearing loss.

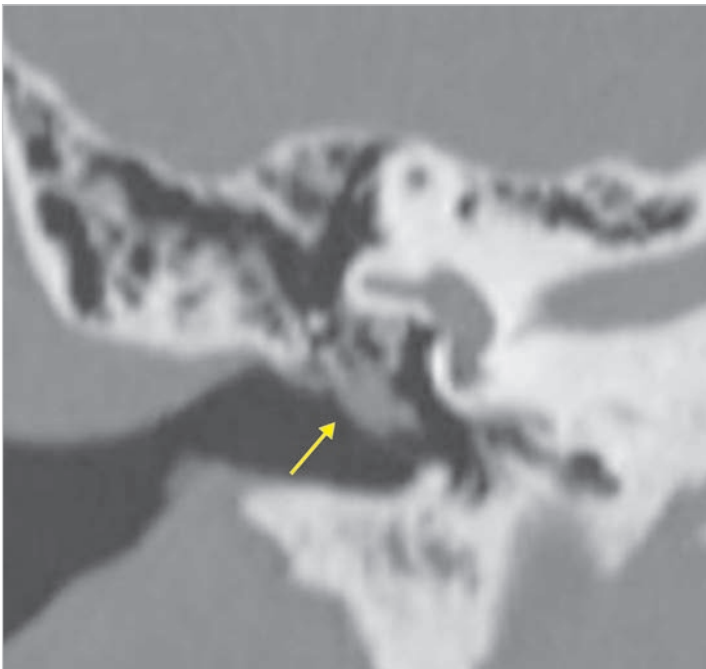


Fig. 2.48 CT scan of the same case, coronal view. The cholesteatoma mass (arrow) erodes the long process of the incus. The superstructure of the stapes is missing.

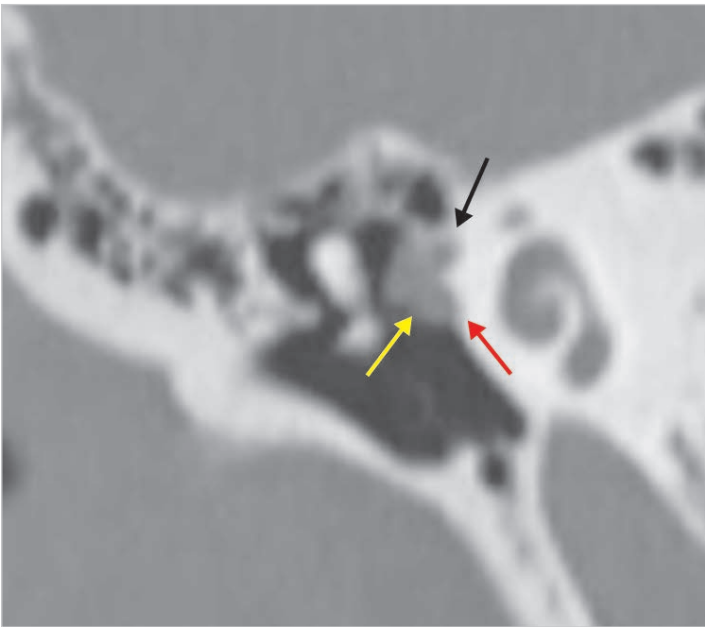


Fig. 2.49 CT scan of the same case, coronal view. The cholesteatoma mass extends to the anterior epitympanic area medial to the malleus (yellow arrow) covering the tympanic segment of the facial nerve (black arrow) and the tensor tympani muscle (red arrow).

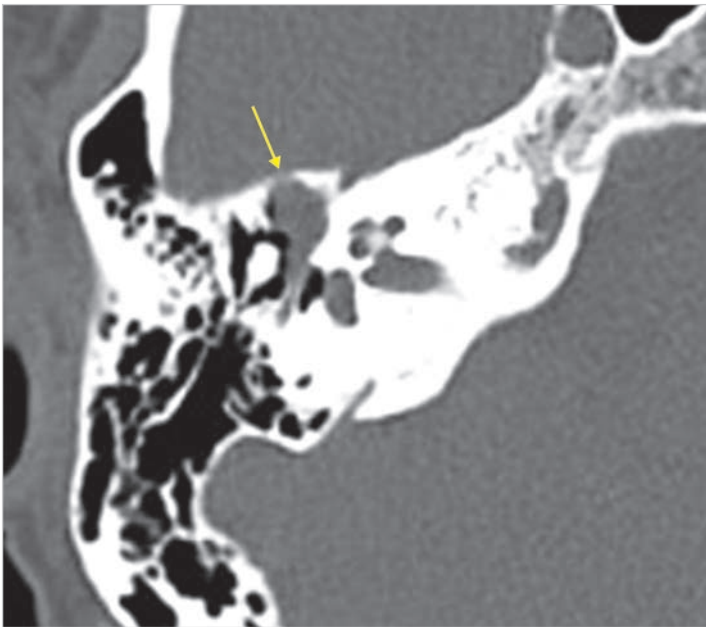


Fig. 2.50 CT scan of the same case, axial view. The cholesteatoma involves the supratubal recess (arrow). The mastoid is free from the disease.



Fig. 2.51 Another case of congenital cholesteatoma (type A/B) evolved slowly in a 40-year-old female patient with no history of otitis. The patient referred to our center for the worsening of a left hearing loss. The whitish mass pushes up the whole tympanic membrane.

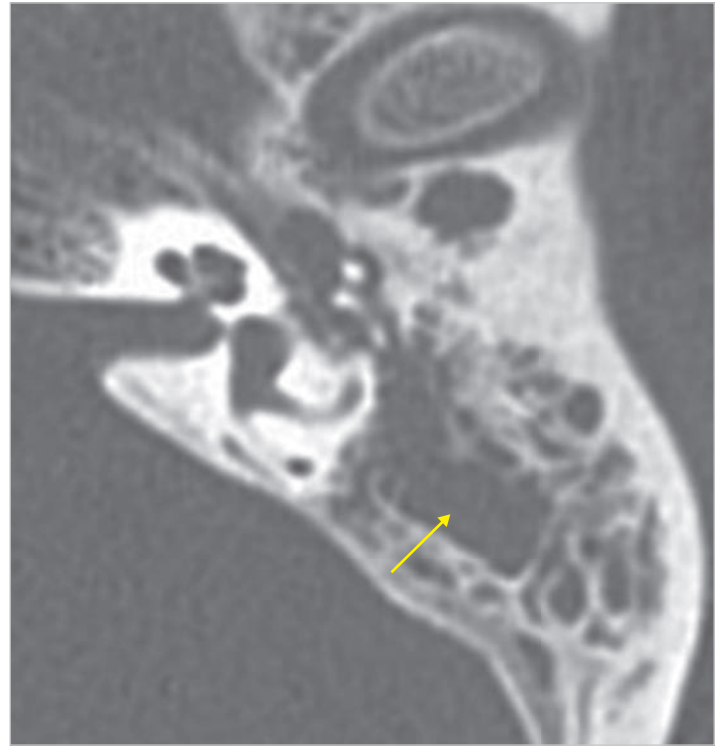


Fig. 2.52 CT scan of the same patient, axial view. The opacification filling the mastoid is seen (*arrow*). It is not possible to differentiate between cholesteatoma and effusion in CT. Presence of cholesteatoma in the mastoid is verified during surgery.

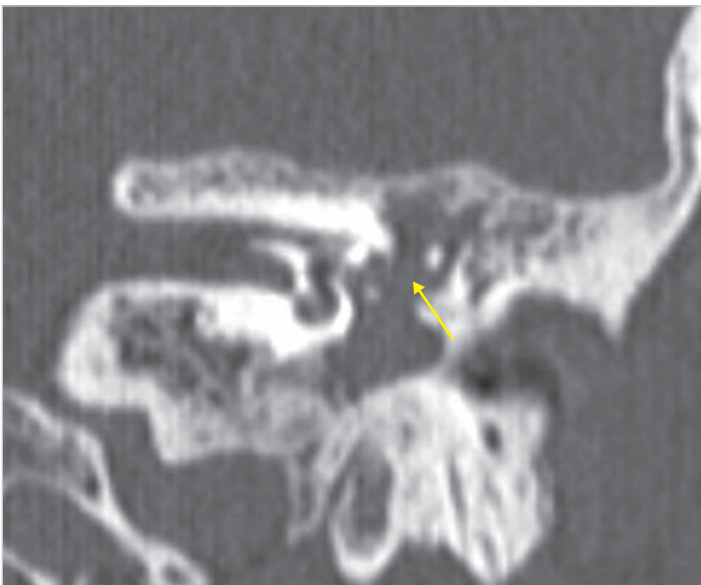


Fig. 2.53 CT scan of the same patient, coronal view. The cholesteatoma erodes incudostapedial joint (*arrow*), resulting in progressive hearing loss.



Fig. 2.54 A case of left congenital cholesteatoma (type A/B) evolved slowly in a 36-year-old man with no history of otitis. The patient complained of aural fullness and hearing loss. A whitish bulge is seen in the posterosuperior quadrant. Audiometry showed slight conductive hearing loss (10–15 dB air–bone gap).

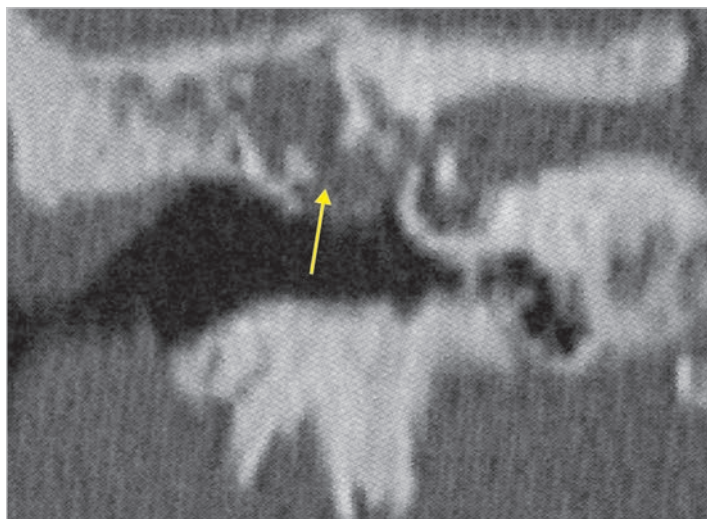


Fig. 2.55 CT scan of the same case, coronal view. The cholesteatoma (*arrow*) involves the posterior epitympanum and the mesotympanic area. The hypotympanum is free of the disease.

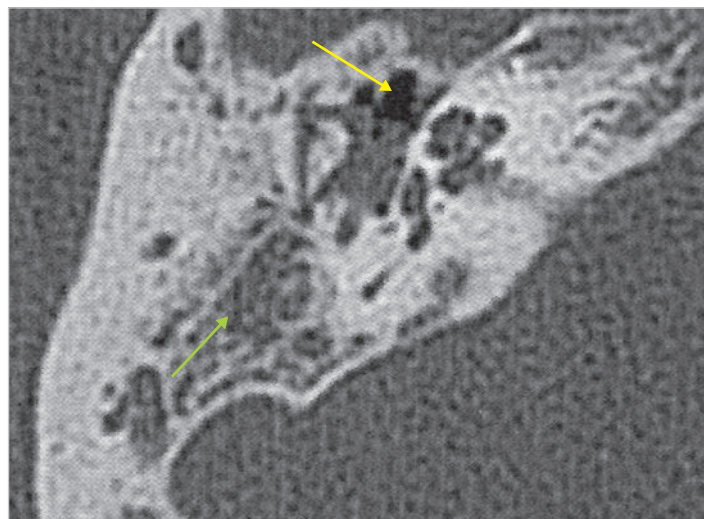


Fig. 2.56 CT scan, axial view, of the same case. The anterior epitympanum is free from the disease (*yellow arrow*), while the mastoid (poorly pneumatized) is opacified (*green arrow*). Presence of cholesteatoma was verified during surgery.

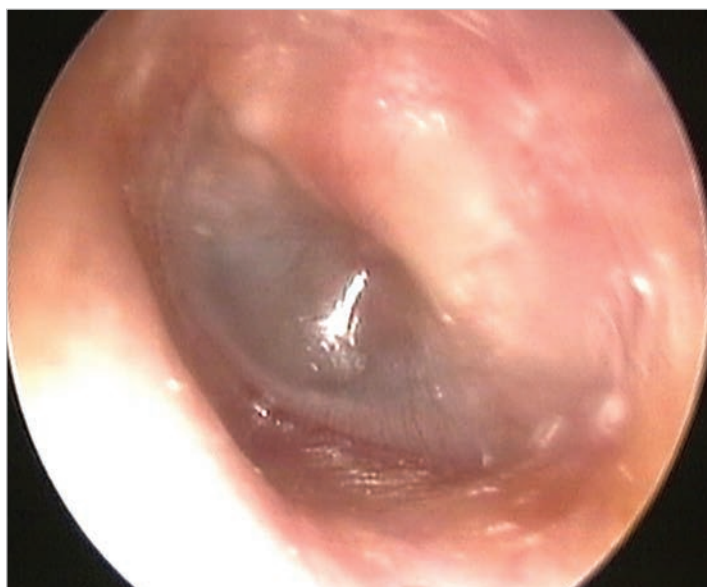


Fig. 2.57 Congenital cholesteatoma in a 7-year-old boy presenting with left hearing loss. The otoscopy shows a classic whitish retrotympenic mass.

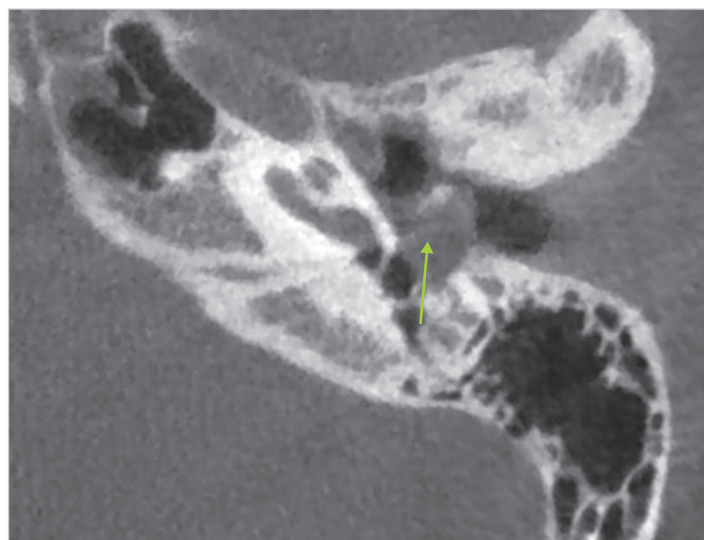


Fig. 2.58 Cone-beam CT scan of the same case, axial view. The presence of a mesotympanic retromalleolar cholesteatoma (type A2) engulfing the incudostapedial joint is confirmed. A staged canal wall up (closed) tympanoplasty was performed.

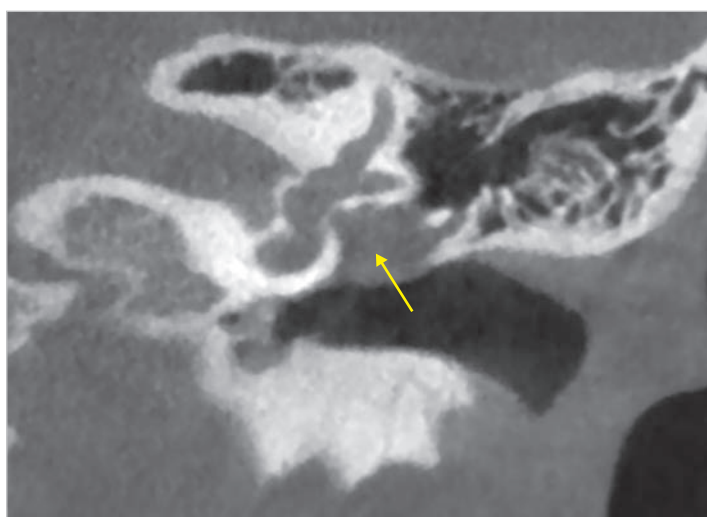


Fig. 2.59 Cone-beam CT scan of the same case, coronal view. The cholesteatoma involves the mesotympanic area, eroding the incudostapedial joint (*arrow*).

2.7 Petrous Bone Cholesteatoma

Petrous bone cholesteatomas (PBCs) are slow-growing epidermoid lesions arising in the petrous portion of the temporal bone with an incidence of 4 to 9% of all petrous pyramid lesions. These could be congenital, acquired, or iatrogenic. In congenital ones, the first symptoms can be facial nerve paralysis, vertigo, and deaf ear. Fetid otorrhea, progressive facial palsy, vertigo, and hearing loss of any type (conductive, sensorineural, mixed) are usually encountered in these patients. Refer to ►Fig. 2.60, ►Fig. 2.61, ►Fig. 2.62, ►Fig. 2.63, ►Fig. 2.64, ►Fig. 2.65, ►Fig. 2.66, ►Fig. 2.67, ►Fig. 2.68, ►Fig. 2.69, ►Fig. 2.70, ►Fig. 2.71, ►Fig. 2.72, ►Fig. 2.73.

As mentioned, otoscopy may be irrelevant in petrous bone cholesteatoma. High grade of suspicion is required in such cases, and when a patient presents with some neurological deficit that could be explained by some temporal bone lesions, possibility of petrous bone cholesteatoma should be considered. The MRI is fundamental to diagnose such cases, and CT gives additional information to evaluate extension of the disease.

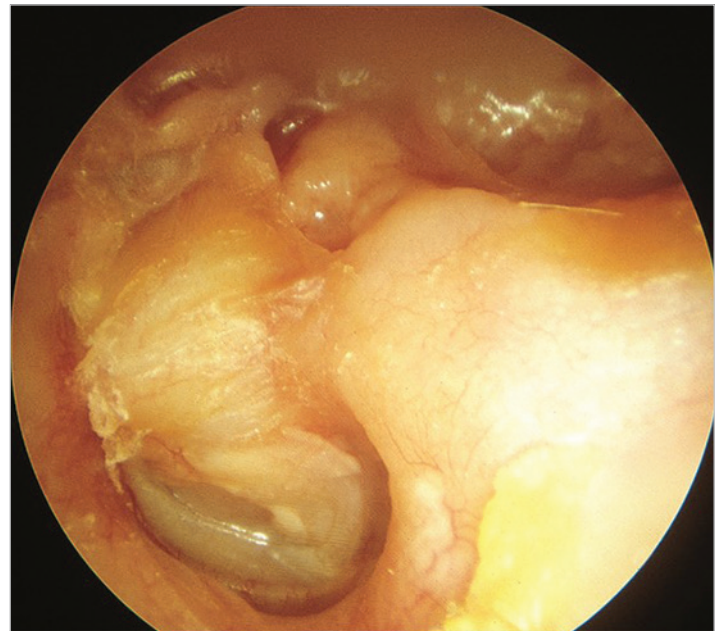


Fig. 2.60 Left acquired or iatrogenic supralabyrinthine petrous bone cholesteatoma in a radical cavity. A whitish retrotympanic mass is seen at the level of the second portion of the facial nerve. The patient presented with progressive facial nerve paralysis and total hearing loss. A correct diagnosis depends not only on otoscopy but also on the symptomatology (facial paralysis, anacusis) and a high-resolution CT scan.

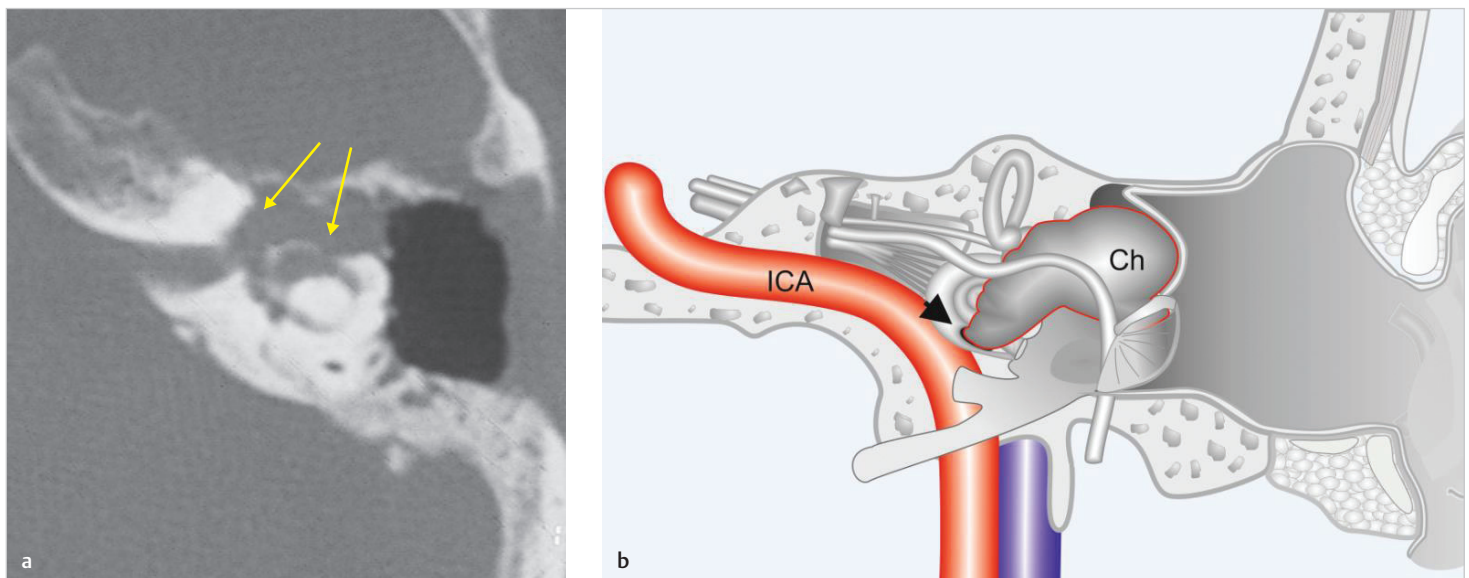


Fig. 2.61 (a) CT scan of the same case, axial section. Involvement of the lateral semicircular canal and the vestibule (arrows) is well visualized. (b) The cholesteatoma invades the cochlea anteriorly, while medially it reaches the fundus of the internal auditory canal. The posterior semicircular canal is not invaded.

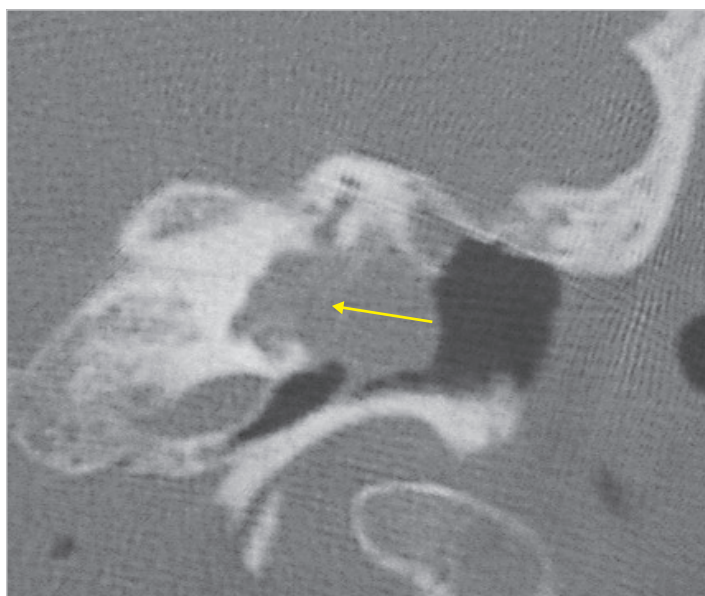


Fig. 2.62 CT scan of the same case, coronal section. The medial extension of the cholesteatoma severely eroding the cochlea can be appreciated (*arrow*).

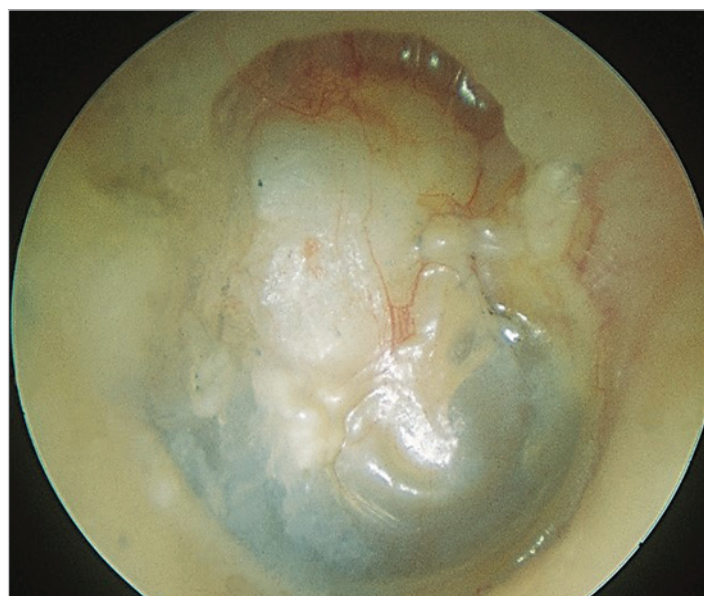


Fig. 2.63 Right acquired supralabyrinthine petrous bone cholesteatoma. A whitish mass is present in the mastoid cavity of an open tympanoplasty. The mass occupies the whole epitympanum and extends interiorly behind the tympanic membrane. The patient presented with ipsilateral facial paralysis and conductive hearing loss.

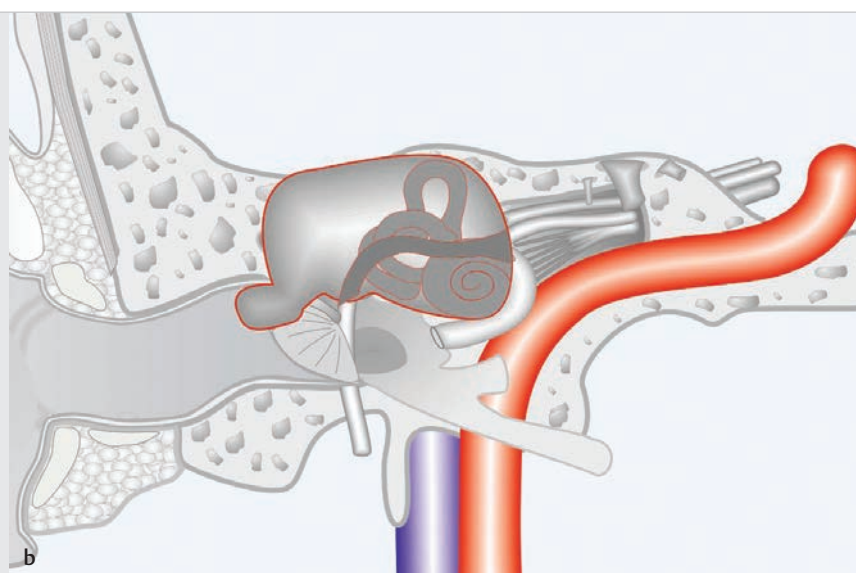
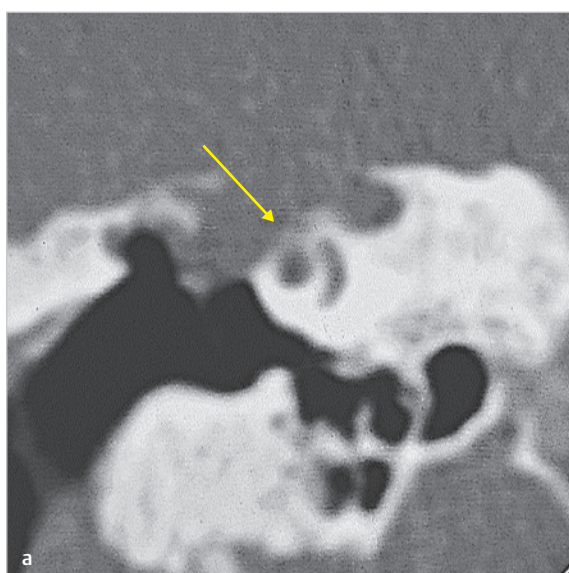


Fig. 2.64 (a) CT scan of the case presented in ► Fig. 2.63 with the relative drawing (b). The cholesteatoma invades the cochlea (*arrow*). Total removal of the pathology was accomplished using a transcochlear approach with obliteration of the operative defect using abdominal fat. The external auditory canal was closed as blind sac. The facial nerve was infiltrated at the level of the geniculate ganglion and was repaired using a sural nerve graft.



Fig. 2.65 Right ear. Another example of right acquired supralabyrinthine petrous bone cholesteatoma. The patient presented with right facial nerve paralysis. Otoscopy reveals a right epitympanic erosion.

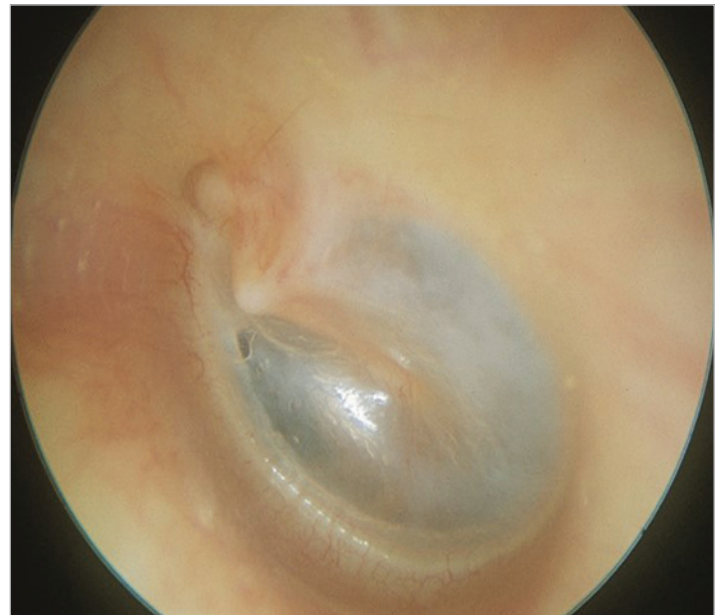


Fig. 2.67 Left congenital supralabyrinthine petrous bone cholesteatoma with extension toward the apex. Otoscopy is negative. The patient complained of progressive facial nerve paralysis of 5 years' duration as well as conductive hearing loss.

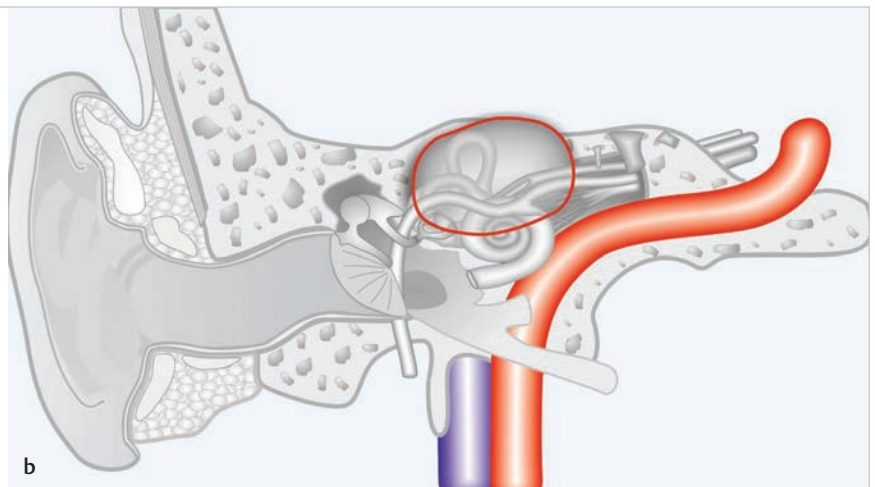
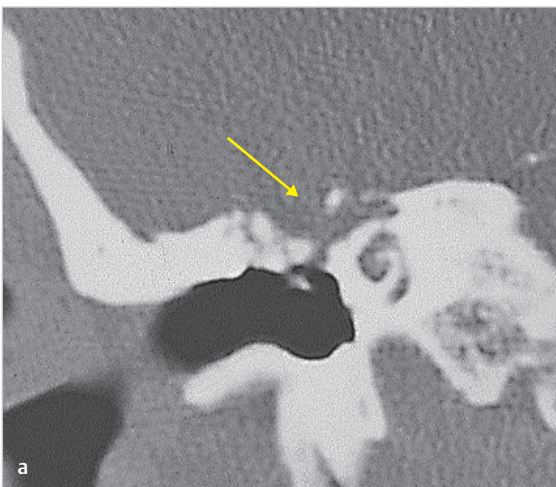


Fig. 2.66 (a) CT scan of the same case, coronal view, with the relative drawing (b). Typical location and erosion of acquired small supralabyrinthine petrous bone cholesteatoma (arrow).

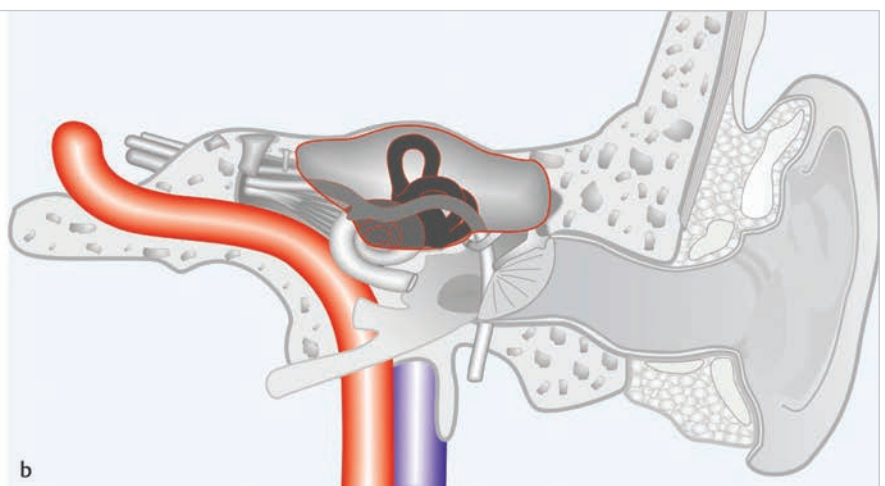
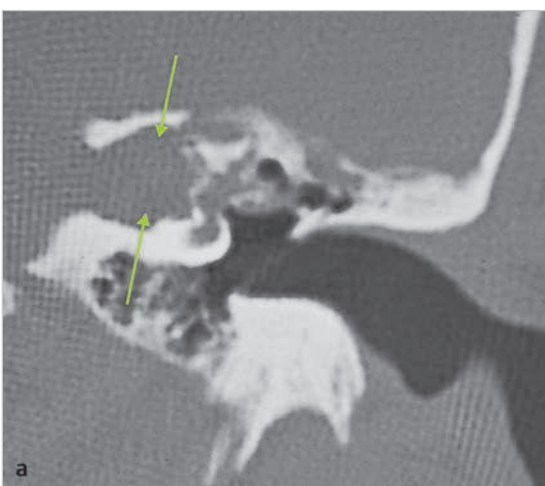


Fig. 2.68 (a) CT scan of the same case with relative drawing (b). Coronal view showing extension of the cholesteatoma into the internal auditory canal (arrows).

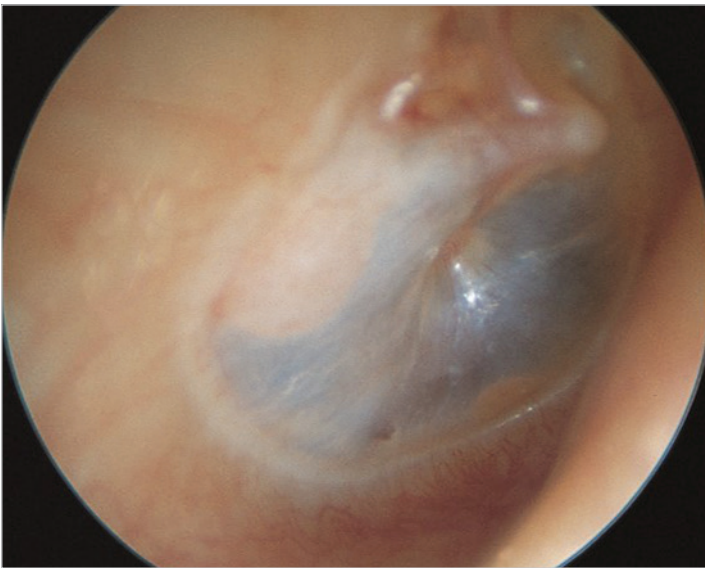


Fig. 2.69 Right congenital infralabyrinthine apical petrous bone cholesteatoma in a 30-year-old female patient. In the posterosuperior quadrant, a white retrotympanic view is observed. The patient had complained of right anacusis since childhood and instability of 1-year duration. The facial nerve was normal.

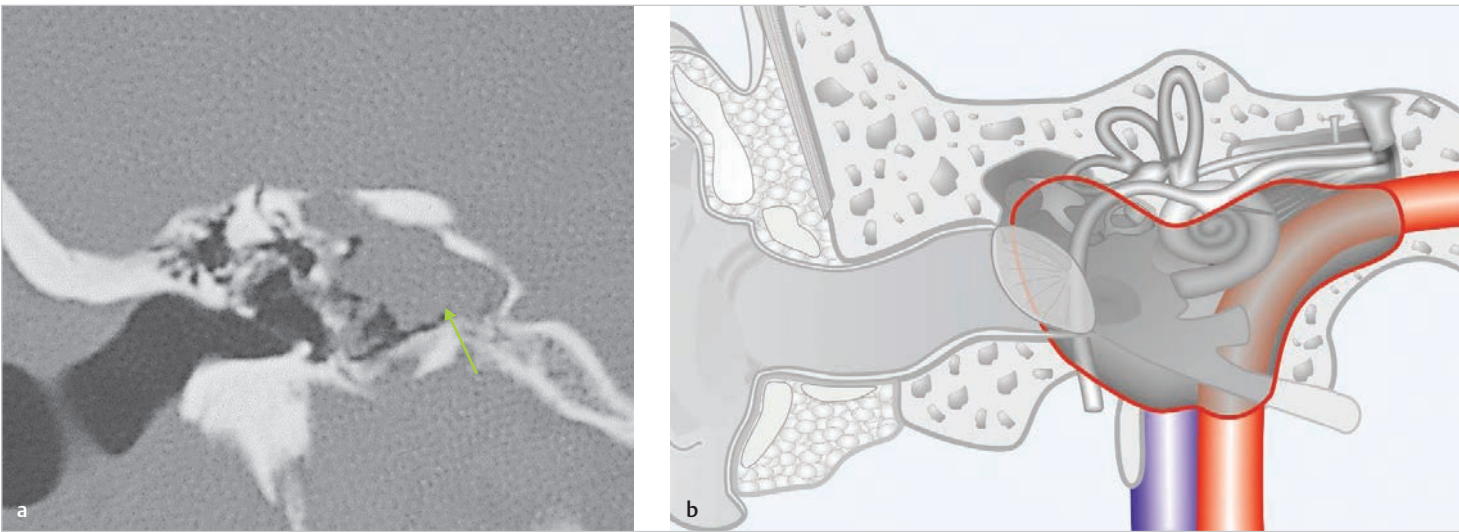


Fig. 2.70 (a) CT scan of the same case with relative drawing (b). The coronal view demonstrating the involvement of the infralabyrinthine apical compartment by the cholesteatoma (arrow).

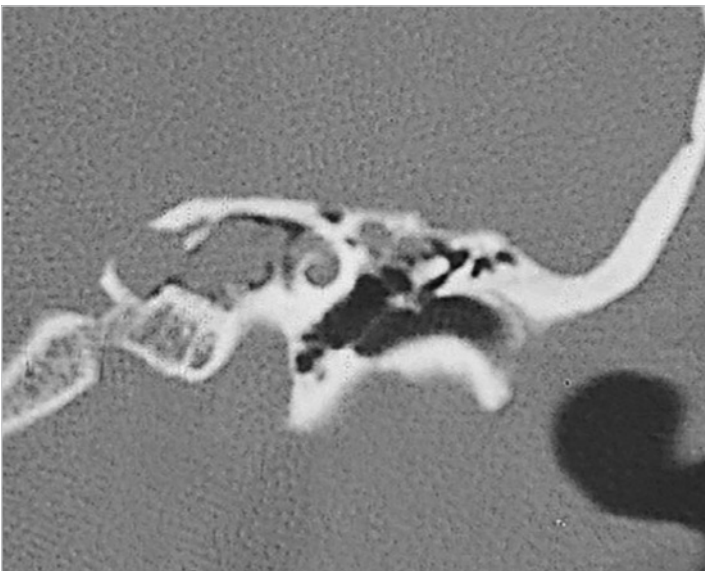


Fig. 2.71 A more anterior section of the CT scan at the level of the cochlea. The internal auditory canal is completely infiltrated.



Fig. 2.72 Left ear. Polyp in the external auditory canal in a patient presented with otorrhea and sensorineural hearing loss. The patient had undergone a myringoplasty before.

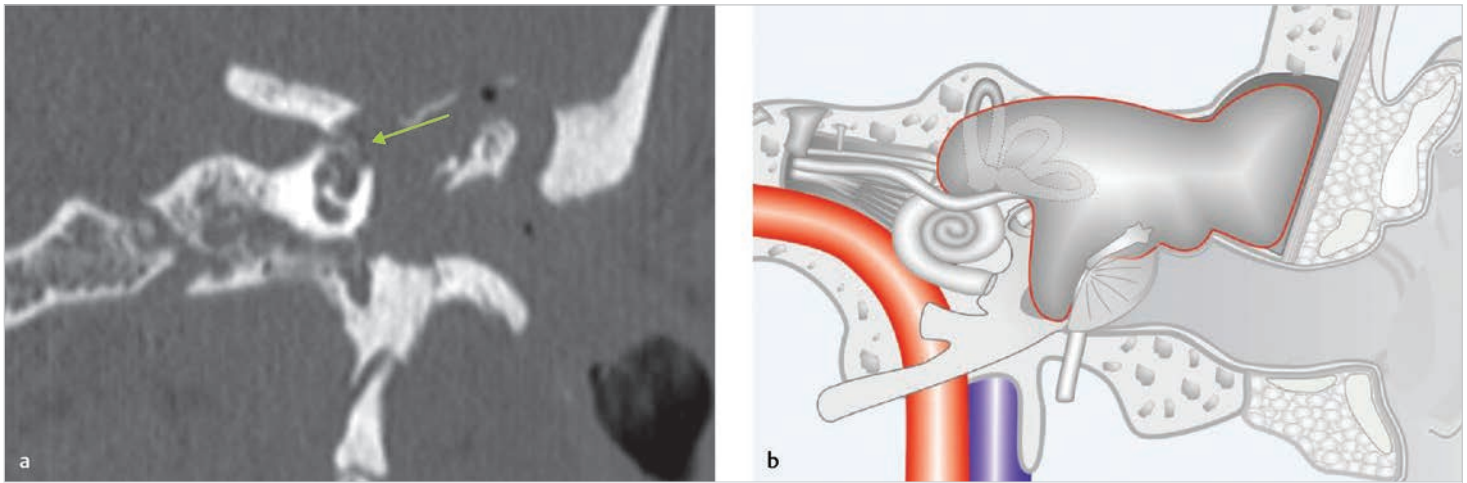


Fig. 2.73 (a) CT scan of the same case, coronal view, with relative drawing (b). A cholesteatoma involving the basal turn of the cochlea is seen (arrow).

2.7.1 Differential Diagnosis

Petrous apex lesions can be either primary, arising from the petrous apex or secondary either as metastasis or direct extension from adjacent areas. Primary lesions include cholesterol granuloma, petrous bone cholesteatoma, petrous apex effusion, internal carotid artery aneurysm, and chondrosarcoma. Secondary lesions include chordoma, paraganglioma, neuromas, meningiomas, osteomyelitis of the temporal bone, and metastases.

The majority of neoplastic lesions in the temporal bone shows gadolinium enhancement in MRI, and they usually infiltrate the temporal bone in destructive fashion. However, differential diagnosis between cholesteatoma, cholesterol granuloma, collection of effusions in pneumatized cells, and bone marrow remains further radiological inspection. Typical appearance of cholesteatoma on CT is expansive growth with round-shaped clear margin. On MRI, T1 gives low signal, and T2 gives moderately high signal. No enhancement with gadolinium is observed inside of it. Distinguishable appearance can be obtained in diffusion-weighted modality, that is, cholesteatoma shows very high signal.

Cholesterol granuloma is by far the commonest petrous apex lesion. On CT scan, it appears as a smoothly marginated expansile lesions, isodense with the brain tissue without contrast enhancement. It is usually difficult to differentiate these lesions

from petrous bone cholesteatoma on CT scan. However, on MRI, distinction is usually possible as cholesterol granuloma show a typical hyperintense signal on T1 (► Fig. 2.28).

Effusion within a pneumatized petrous apex is probably due to trapped fluid from previous otitis media. Opacified air cells show high T2 signal. On T1, the signal is usually hypointense, with a rim of gadolinium enhancement reflecting surrounding mucosal hyperemia. It appears on CT scan as a soft tissue density filling an air cell tract without causing bone destruction (► Fig. 2.78). Some cases with high protein content will present with an intermediate or even high signal on T1, mimicking cholesterol granuloma. In these latter cases, the absence of bone destruction and the lack of an expansile lesion confirm the diagnosis.

Normal bone marrow in the petrous apex may mimic some pathology in MRI if pneumatization of petrous apex is asymmetrical. Different from other nonenhanced lesions, the bone marrow is usually hypointensity in T2 images, and on CT, septa in the petrous apex is preserved without expansive growth.

In all radiological examinations, there are exceptions and unusual findings. Do not diagnose lesions based only on one modality. MRI and CT work in a complementary fashion, and careful interpretation of all available modality is indispensable to diagnose skull base lesions.

Refer to ► Fig. 2.74, ► Fig. 2.75, ► Fig. 2.76, ► Fig. 2.77, ► Fig. 2.78.

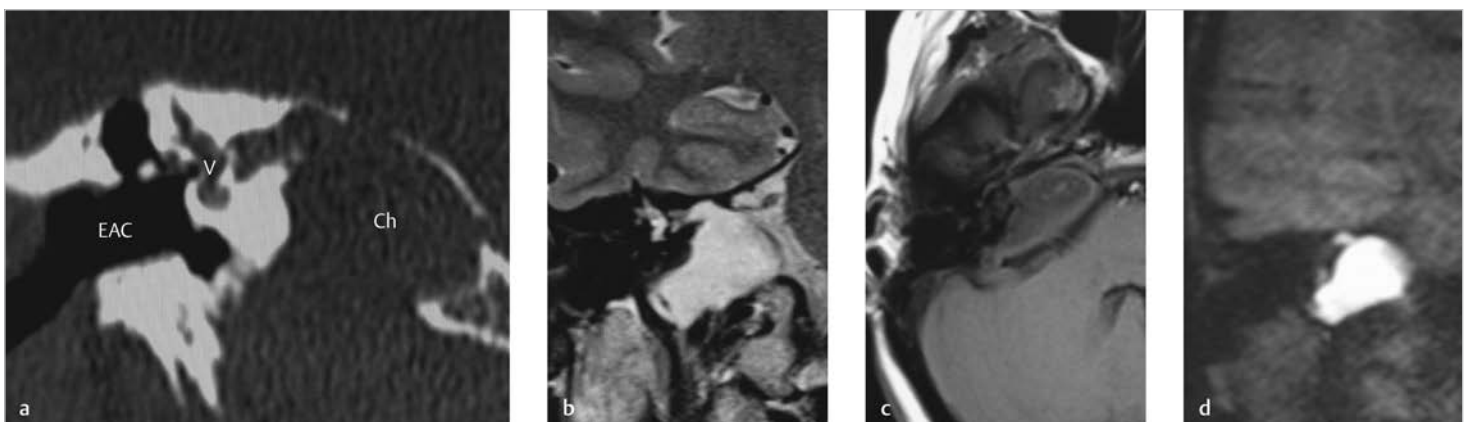


Fig. 2.74 Infralabyrinthine-apical petrous bone cholesteatoma as shown in Case 14.19 in Chapter 14. The coronal CT (a) shows expansive growth of a large round-shaped lesion in the petrous apex. (b) The lesion shows high signal in T2 image, and (c) low in T1. (d) In diffusion-weighted image, very high signal corresponding with cholesteatoma is identified. Ch, cholesteatoma; EAC, external auditory canal; V, vestibule.

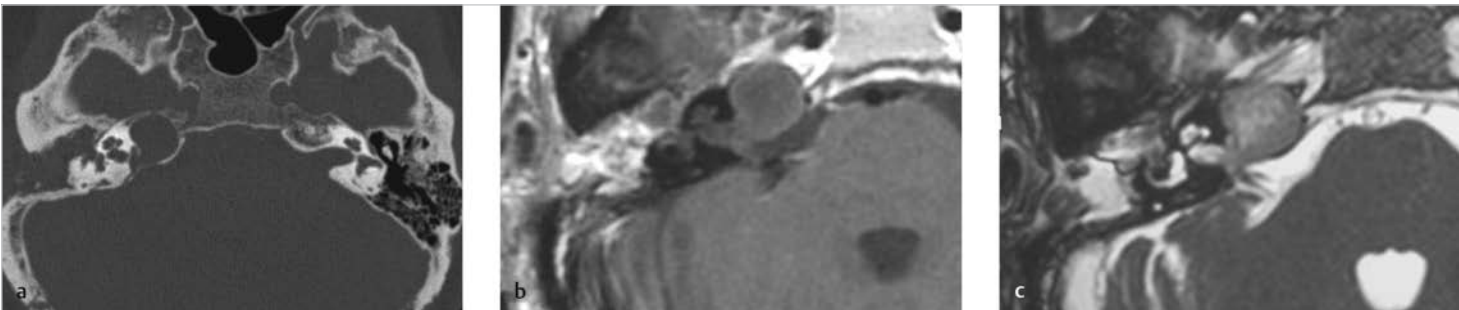


Fig. 2.75 A case of right petrous apex cholesteatoma. (a) The CT shows expansive growth of a round-shaped lesion in the petrous apex of the temporal bone with a formerly operated open cavity. (b) The lesion shows slightly low signal in T1 image with gadolinium enhancement, (c) and slightly high signal in T2. Note faint enhancement in the margin of the lesion with no enhancement inside, and obvious enhancement in inflamed open cavity.

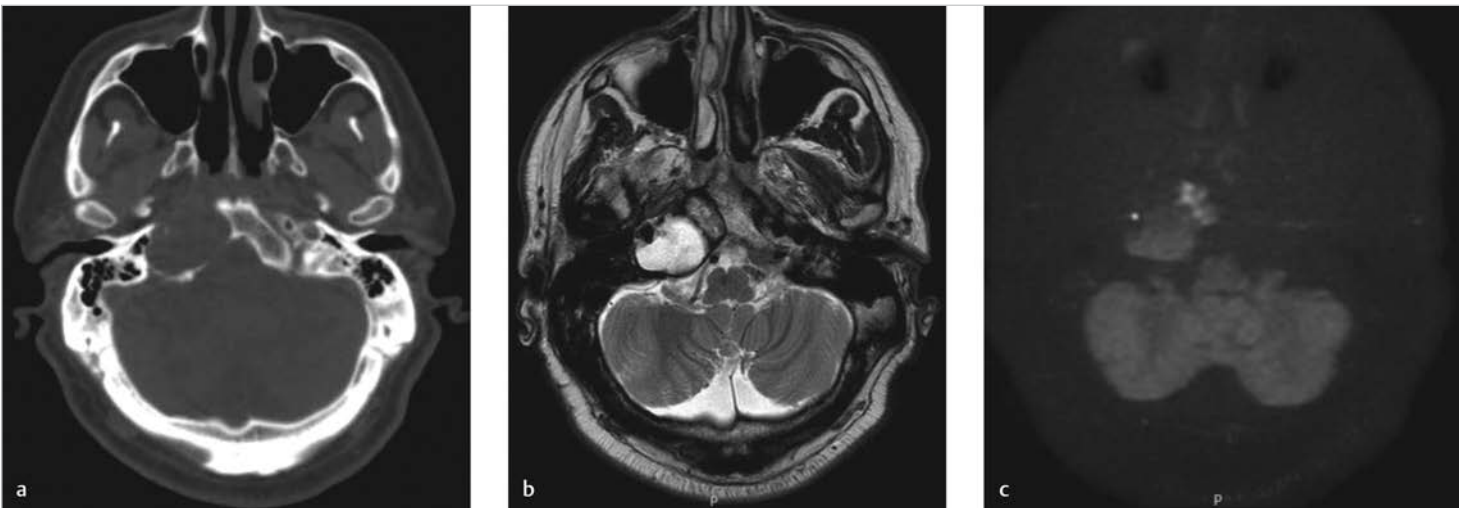


Fig. 2.76 A case of right petrous apex cholesterol granuloma. (a) The CT shows expansive growth of a round-shaped lesion in the right petrous apex. (b) The lesion shows very high-signal intensity in T1 image. (c) In contrast to cholesteatoma, the diffusion-weighted image demonstrated low signal in the lesion. The high signal medially to the granuloma does not mean coexistence of cholesteatoma, and probably means some pathological change in bone marrow (see also ► Fig. 11.15–2).

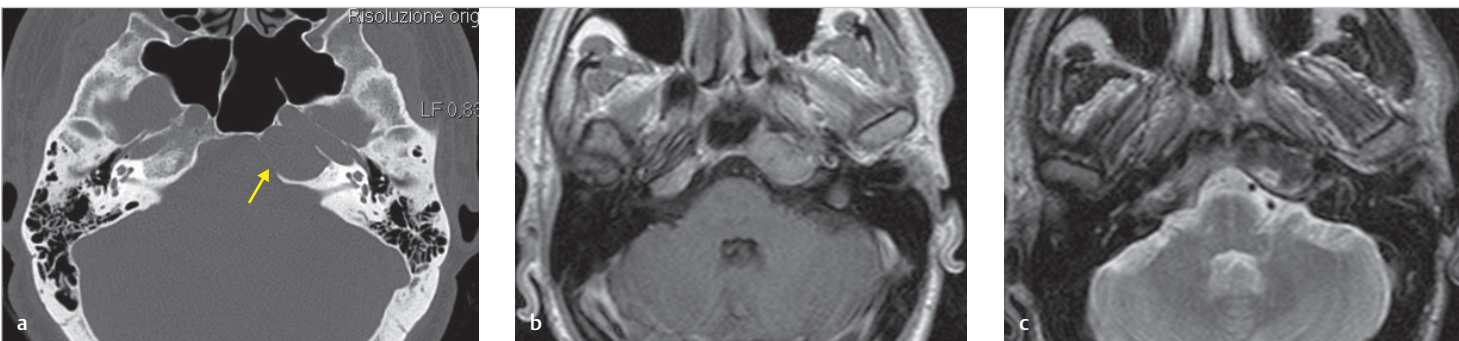


Fig. 2.77 A case of right petrous apex cholesterol granuloma. (a) The CT shows expansive growth of a round-shaped lesion in the left petrous apex (arrow). (b) The lesion shows high-signal intensity in T1 image with faint enhanced with gadolinium in its thin wall. (c) Different from usual cholesterol granulomas, the contents of the lesion show low signal in T2. Because of its proximity to the sphenoid sinus, endoscopic transnasal approach is applied, and presence of cholesterol granuloma was verified.

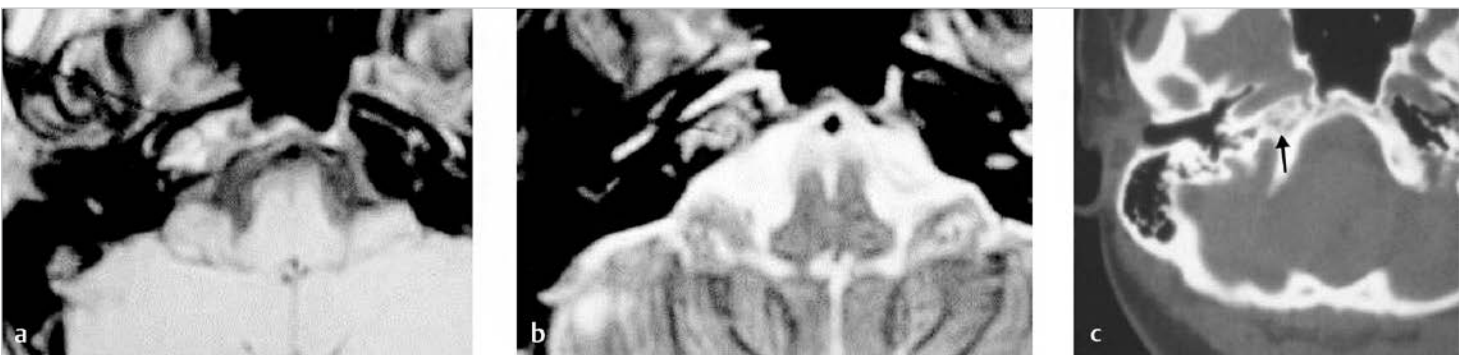


Fig. 2.78 Imaging of a case of right petrous apex effusion. A hyperintense lesion involving the petrous apex is seen on both T1 without (a) gadolinium and (b) T2 image. Note that there is no expansion of the petrous apex. (c) The CT scan shows preserved bony septa between apical air cells.

3 Operating Room Setup and Anesthesia for Middle Ear Cholesteatoma Surgery

3.1 Operating Room Setup

3.1.1 Arrangement of the Room

The operating room setup is shown in ► Fig. 3.1, ► Fig. 3.2, and ► Fig. 3.3. The surgeon sits beside the bed on the side of the operated ear. The scrub nurse is located opposite side of the surgeon. The instrument table is located in front of the nurse. This position allows the nurse to deliver required instruments to both hands of the surgeon, and to offer required materials within the operative site without interfering with surgeon's hands. In this way, the exchange between the nurse and the surgeon can be carried on without leaving a view under the microscope (► Fig. 3.2).

The microscope is positioned at the top of patient's head to gain maximum adjustability. To enable these arrangements, position of the anesthesiologist should be away from the patient's head, beside his legs. The intravenous infusion stand is placed in the same side, in front of the anesthesiologist. The scrub nurse controls the drill foot pedal, the bipolar and monopolar coagulator, and water irrigation. Each instrument is operated by the order of the surgeon vocally. In this way, the surgeon can concentrate on the operating field. A television monitor is placed where the scrub nurse can watch comfortably. The monitor will enhance recognition of the microsurgical process and allow appropriate assistance including choice of instruments, timing of switching, and flow rate of irrigating water.



Fig. 3.1 Operating room during middle ear surgery.

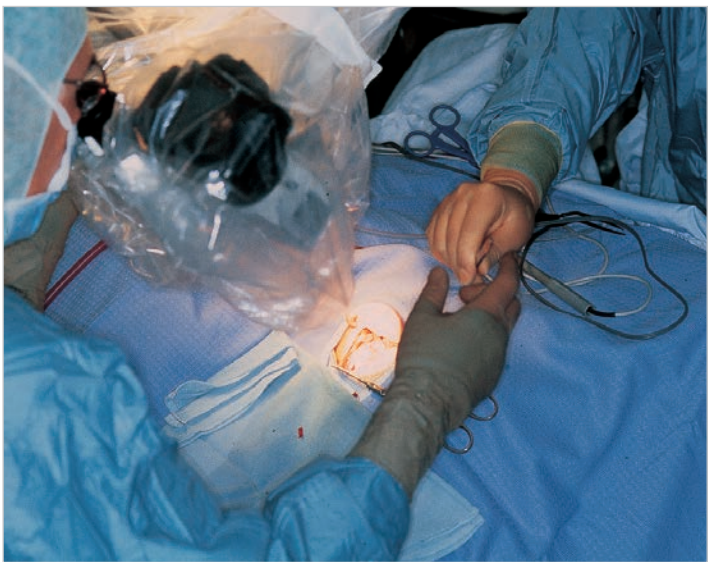


Fig. 3.2 Scrub nurse passing an instrument to surgeon.

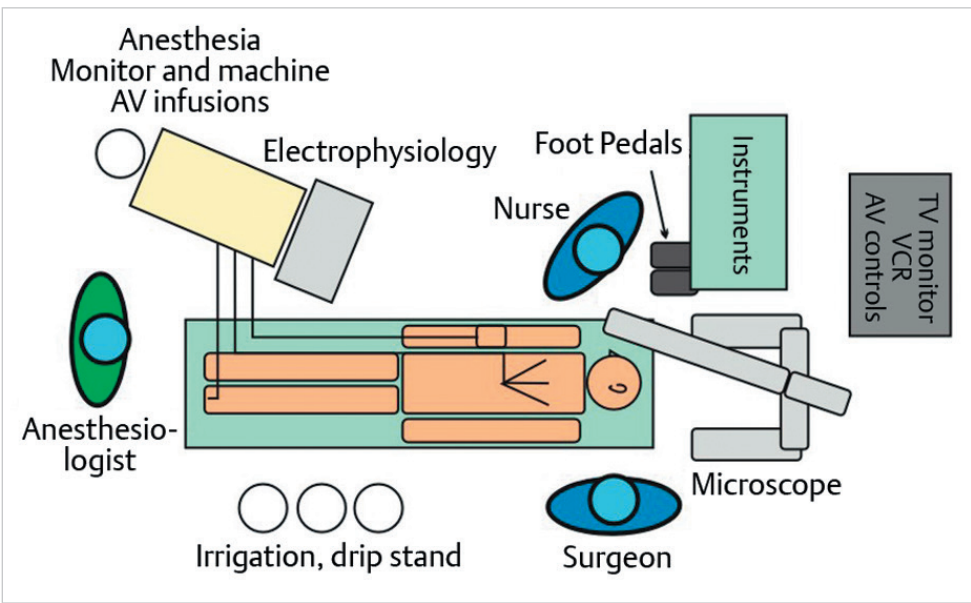


Fig. 3.3 Arrangement of the operating room.

3.1.2 Position of the Patient

The patient is placed in a supine position on the surgical bed that can tilt back and forth, and head down and up. The head of the patient is turned to the contralateral side. Usually, no pillows are used as far as the patient is comfortable. However, in obese patients and in patients with short neck, the chest of the patient sometimes disturbs movement of the surgeon's elbow. This gives more trouble when the operated ear is on the same side as the surgeon's favorite arm. A thin pillow is used in such cases, or in patients with cervical problems to set the proper position.

Because of complex three-dimensional anatomy, middle ear surgery requires frequent change of surgical angle between microscope and the operating field. On the other hand, under local anesthesia, the patient should recognize necessity of keeping his or her head still throughout the surgery, and frequent order to the patient to move his or her head is dangerous. The bed, rather than the microscope, is tilted toward any directions (► Fig. 3.4). In that way, the surgeon can keep in an ergonomic and relaxed position that allows good work. For this purpose, the patient is tied to the bed at the wrists and thighs with safety belts. If control of structures located in the posterior mesotympanum is required, the bed is tilted toward the surgeon. For example, in

ossiculoplasty in the second stage surgery, patients spend most of time in this position (► Fig. 3.5). If the area of the anterior epitympanum or the eustachian tube should be controlled, the bed is tilted to the other side of the surgeon (► Fig. 3.6).

In considerable time during surgery, the patient's head is lowered. That position has an advantage in controlling the majority of the important structures such as the facial nerve, the oval window, the ossicular chain and the attic, which are located in superior half to the middle ear (► Fig. 3.4). Since the position raises venous pressure of the operating field slightly, appropriate execution of hemostatic techniques need to be employed (see Chapter 4.1.3).

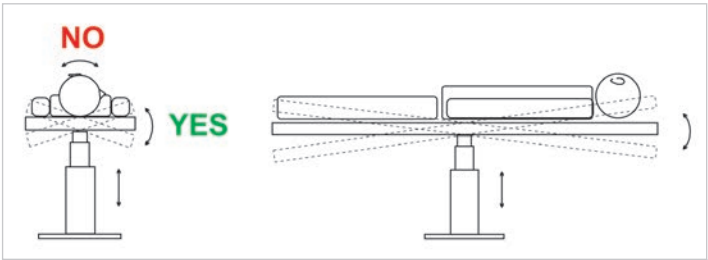


Fig. 3.4 Adjustment of the patient's position.

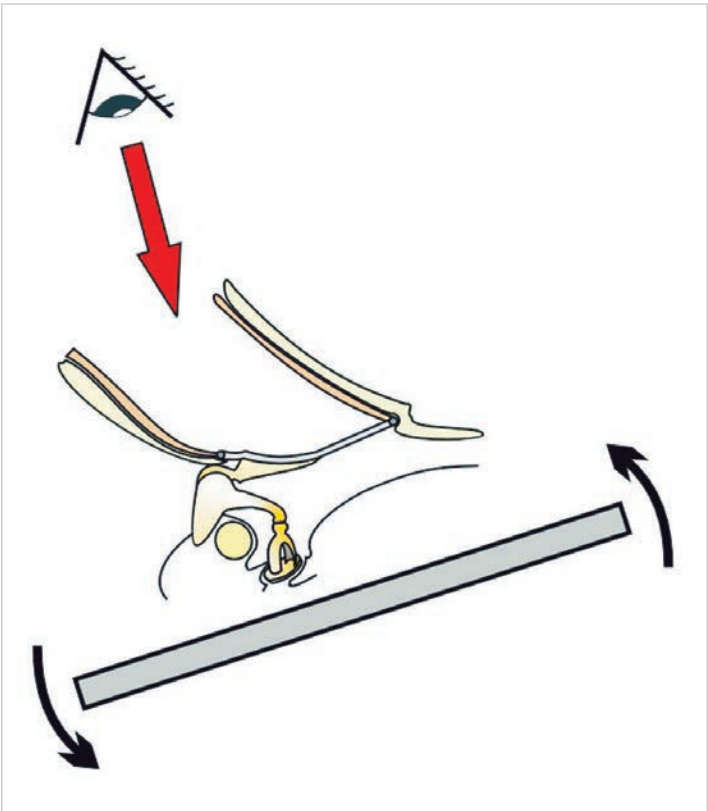


Fig. 3.5 Control of the posterior mesotympanum.

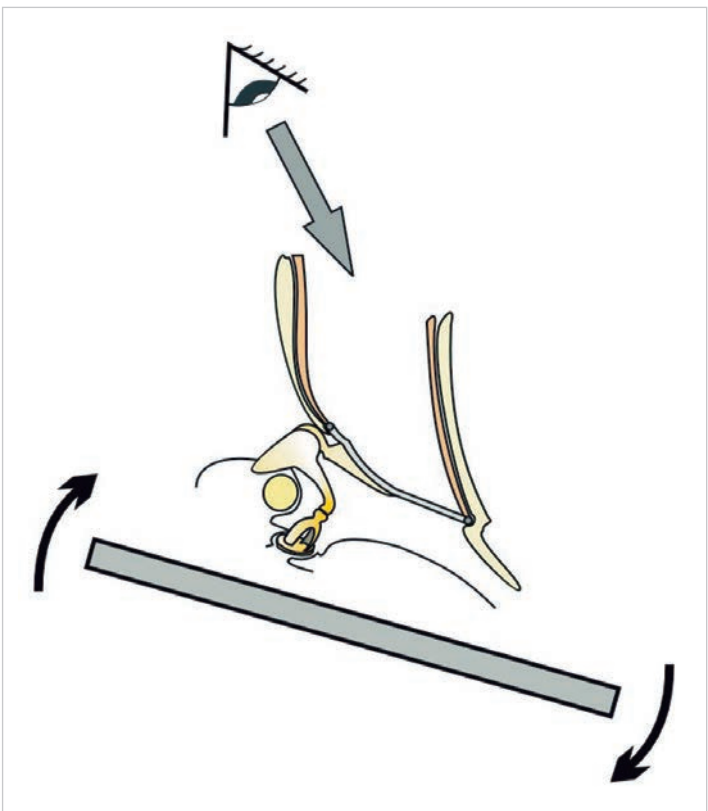


Fig. 3.6 Control of the anterior epitympanum and protympanum.

3.1.3 Preparation of the Operative Site

If a retroauricular incision is needed, the operative site is prepared by shaving the patient's hair approximately two fingers from the attachment of the auricle (► Fig. 3.7). In transcanal approach, no haircut is necessary. Adhesive tape is used to secure remaining hair (► Fig. 3.8).

The local anesthetic solution is injected into the operative site in the way described below (see Chapter 3.2.1). Then, sterilization is performed by a solution containing 70% ethanol with 0.25% benzalkonium chloride (Citrosil, Glaxo, Italy). The patient is draped in layers using sterile cloths with adhesive tape. The last drape with a hole is placed in the center to expose the operative site (► Fig. 3.9). Finally, an intensive lavage of the external auditory canal with Citrosil, 70% ethanol, and water is conducted.

3.1.4 Position of the Surgeon

The position of the surgeon is like a F1 pilot. The surgeon should stay in narrow area limited by the small operating field, but he or she should be placed as comfortable as possible to conduct precise manipulations for long time. The chair for the surgeon should have wheels to move freely with no impediment on the floor. Height of the chair should be adjustable. The surgeon should sit comfortably, well supported by a backrest that is draped. Distance between the surgeon and the operated ear should be within easy reach, making the operator's elbows anatomically comfortable. This position allows the surgeon to keep meticulous concentration on operating field throughout the surgery. Surgeon's legs are covered by the last drape to keep operating field clean and to hold instruments in case they slip down from the operating field. Right position (► Fig. 3.10) and emphasized wrong position (► Fig. 3.11) are shown.

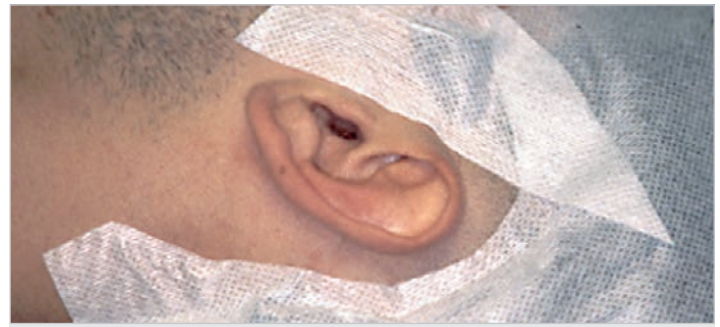


Fig. 3.7 Preparation for retroauricular approaches.



Fig. 3.8 Preparation for transcanal approaches.



Fig. 3.9 After draping and sterilization with Citrosil.



Fig. 3.10 Right position.



Fig. 3.11 Wrong position.

3.1.5 Position of the Surgeon's Hands

To maintain precise and fine manipulation throughout operation, position of the surgeon's hands is of tremendous importance. The hands are placed on the patient's head with one's wrists straight, but not rigid, without obstructing surgical field. The surgeon's arm of the operated side is placed on patient's shoulder. Most of the instruments are held like a pen, but the superior aspect is not covered with fingers to obtain maximum view. Make sure that, especially near the delicate structures, a part of surgeon's hand is supported by somewhere stable. This enhances precise manipulation without tremor, and in long operations, it avoids tension of the back, neck, and arms.

There are some differences in position of the hands, depending on approaches performed. Since retroauricular incision allows

wide approach, surgeon can place his or her hands in more relaxed position with maximal support from the patient's head and the body, keeping some distance between both wrists and hands (► Fig. 3.12, ► Fig. 3.13).

On the other hand, in transcanal and transmeatal approaches in which an ear speculum is used to establish access to the middle ear, the surgical angle is limited by the speculum. The distance between both hands is kept closer, and distance between the surface of the patient's head and fingers holding instruments should be maintained larger to avoid blocking surgical view with the fingers. The middle finger of the favorite hand is placed on the edge of the ear speculum to obtain maximal support in such limited condition (► Fig. 3.14, ► Fig. 3.15).

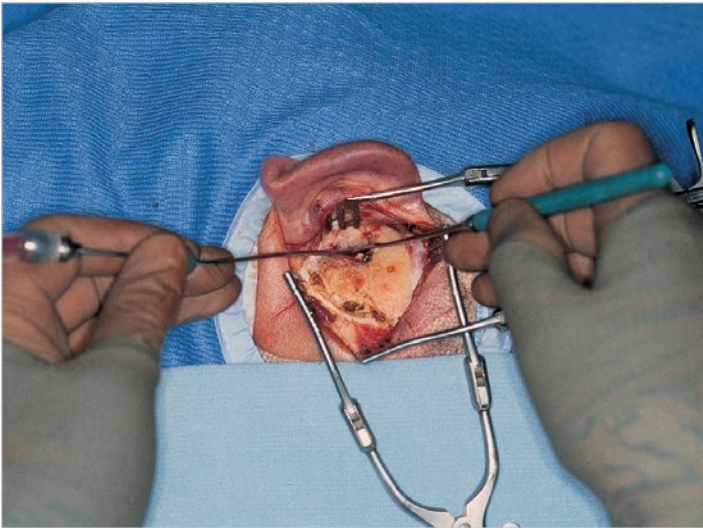


Fig. 3.12 Myringoplasty with a raspatory and a suction tube.

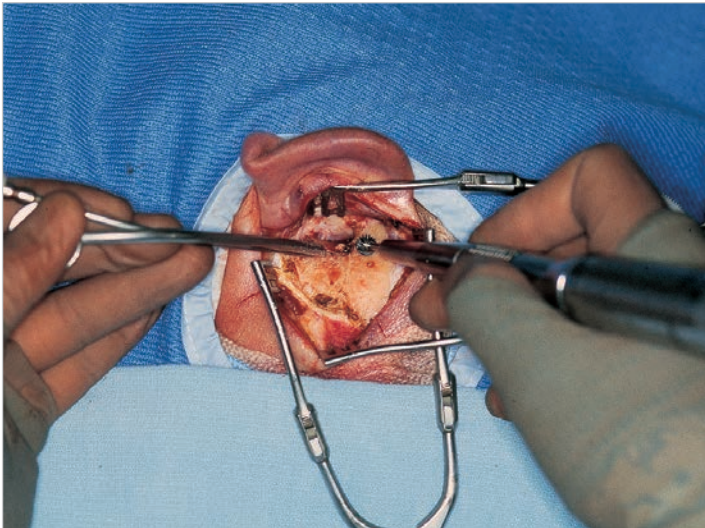


Fig. 3.13 Tympanoplasty with a drill and a suction irrigator.

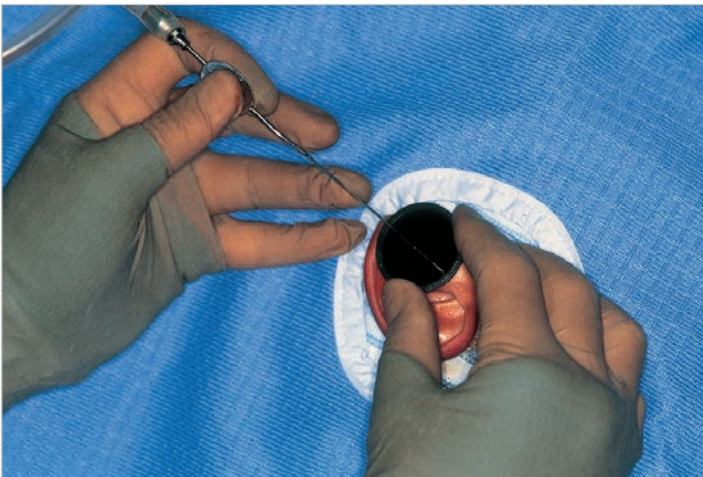


Fig. 3.14 Second stage and stapes surgery with a suction tube.

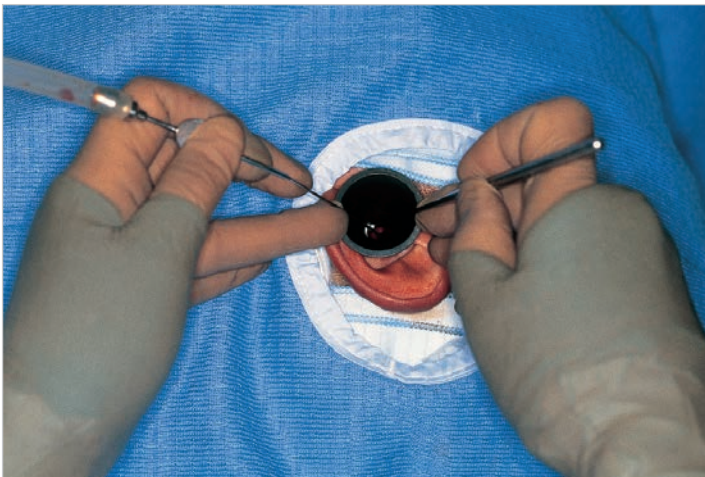


Fig. 3.15 Second stage and stapes surgery with an instrument and a suction tube.

3.1.6 Suction and Irrigation

Suction irrigator is used when extensive bone work such as mastoidectomy is indicated. For that purpose, special suction tubes with irrigator are chosen. In cases of minimal bone work such as stapes surgery, myringoplasty or second stage ossiculoplasty, suction tips with finger control without irrigation tube are used. Intermittent irrigation using a syringe are usually sufficient to keep clear operating field. Fine suction tips are used in narrow area and around delicate structures. The Blackman type suction irrigators that have small holes beside their tip to avoid excessive sucking are used in management of very delicate structures such as labyrinthine fistula (► Fig. 3.16).

3.1.7 Bipolar and Monopolar Coagulation

The monopolar coagulation is used during the initial hemostasis in the skin and subcutaneous soft tissue since the instrument allows not only to coagulate but also to cut soft tissue. The bipolar coagulation should be used around delicate middle ear structures such as the facial nerve, the sigmoid sinus, and the dura, since the equipment allows precise coagulation with minimal risk of spreading current and heat to surrounding structures.

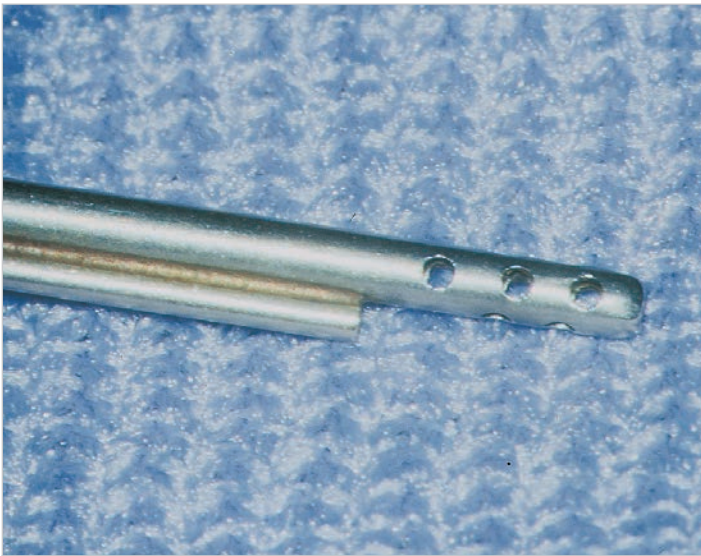


Fig. 3.16 The Blackman type suction irrigator (modified) is safer choice when working around a labyrinthine fistula.

3.1.8 Microscope

The operating microscope for middle ear surgery (Zeiss S21) is equipped with objective lenses that have focal length of 250 mm (► Fig. 3.17). Eyepieces are fixed straight to the light axis to keep relationships of the surgeon, surgeon's hands, and operating field constant. A still camera and a 3CCD camera are mounted on the microscope. The 3CCD camera is connected to a monitor, a video recorder, and a digital printer. The microscope is covered with a sterile plastic drape.

3.1.9 Facial Nerve Monitoring

Generally, we do not use facial nerve monitoring in middle ear surgery. The best security system for the facial nerve is a complete knowledge of its anatomy. We think it may even carry risks to beginners. If the surgeon believes he or she is safe with the monitor, he or she may damage the nerve in one rough motion before he or she is warned. On the other hand, it is required in surgeries of malformations since the nerve may run somewhere unexpected.

On the other hand, the facial nerve monitoring is indispensable in petrous bone cholesteatoma surgery with functioning facial nerve, since the surgery almost always requires precise skeletonization or exposure of the nerve to eradicate pathology.



Fig. 3.17 The operating microscope equipped with a still camera and a 3CCD camera.

3.1.10 Instruments

The number of instruments should be limited to minimum. Fewer instruments enable the scrub nurse to find the required one promptly. In addition, the instruments should always be arranged on the instrument table in the same order to facilitate fluent management by the scrub nurse. Preparation of pictures of each instrument table may be helpful. A badly organized

instrument table will frequently disturb the process of surgery and the surgeon's concentration. Instruments for particular surgeries are shown in following figures (► Fig. 3.18, ► Fig. 3.19, ► Fig. 3.20, ► Fig. 3.21, ► Fig. 3.22, ► Fig. 3.23, ► Fig. 3.24, ► Fig. 3.25, ► Fig. 3.26, ► Fig. 3.27, ► Fig. 3.28, ► Fig. 3.29, ► Fig. 3.30, ► Fig. 3.31, ► Fig. 3.32, ► Fig. 3.33, ► Fig. 3.34).

We generally prefer straight instruments to angled ones, including the handpiece of drills, to ensure delicate manipulation.

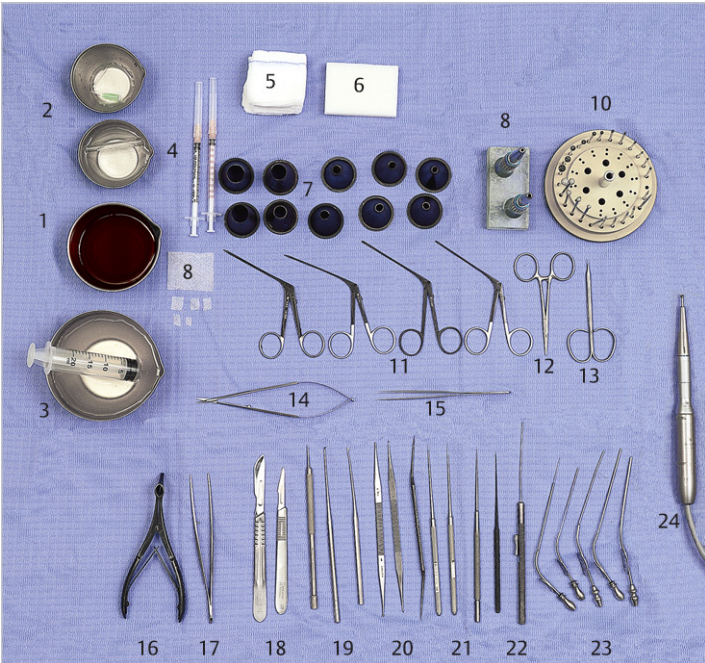


Fig. 3.18 Operating table setup for second stages. 1, citrosil; 2, anesthetic solutions; 3, physiological saline; 4, injectors; 5, folded gauze; 6, gelfoam; 7, ear speculums; 8, cottonoid; 9, handpieces; 10, burrs; 11, microforceps and microscissors; 12, forceps (for incus); 13, tympanoplasty scissors; 14, spring scissors; 15, forceps; 16, nasal speculum; 17, forceps with teeth; 18, scalpels; 19, microdissectors; 20, curettes; 21, hooks and needle; 22, measuring rod; 23, suction tubes; 24, drill.

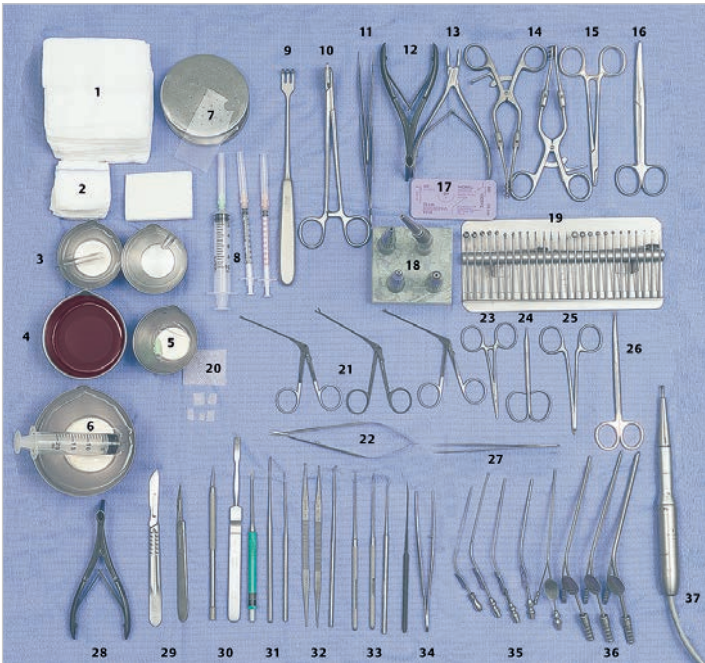


Fig. 3.19 Operating table setup for mastoid surgeries. 1, folded gauze (large); 2, folded gauze (small); 3, anesthetic solutions; 4, citrosil; 5, ethanol; 6, physiological saline; 7, silastic sheeting; 8, injectors; 9, skin retractor; 10, fascia press; 11, forceps (uncutted); 12, nasal speculum; 13, rongeur; 14, self-retaining retractor; 15, forceps (for incus); 16, scissors; 17, vicryl (surgical thread); 18, handpieces; 19, burrs; 20, cottonoid; 21, microforceps and microscissors; 22, spring scissors; 23, forceps (for incus); 24, scissors; 25, malleus nipper; 26, scissors; 27, forceps (fine tip); 28, nasal speculum; 29, scalpels; 30, lempert periosteum elevator; 31, microdissectors; 32, curettes; 33, hooks and needle; 34, forceps with teeth; 35, suction tubes; 36, suction irrigators; 37, drill. This BASCH micromotor (Bien-Air, Switzerland) and the handpiece have recently been replaced with NANO and RAPIDO micromotors and PM2 handpieces produced by the same company.



Fig. 3.20 Ear speculums. Upper row: for transcanal approach (oblique tip). Lower row: for transmeatal approach after meatoplasty.

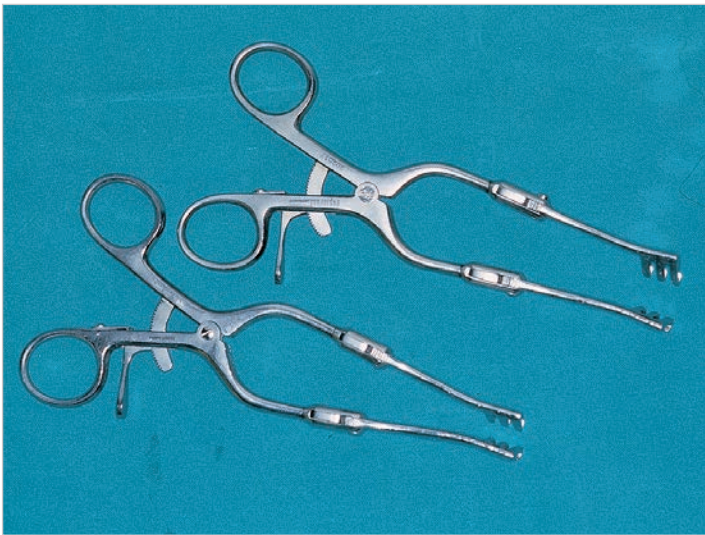


Fig. 3.21 Self-retaining retractors (articulated).



Fig. 3.22 Knives. 1, large blade; 2, small blade with an acute tip; 3, beaver blade.



Fig. 3.23 The NANO and RAPIDO micromotors with angled and straight PM2 handpieces (Bien-Air, Switzerland). These model permits precise bone removal due to their ergonomic design, increased power, and higher maximum speed reaching 80,000 rpm.

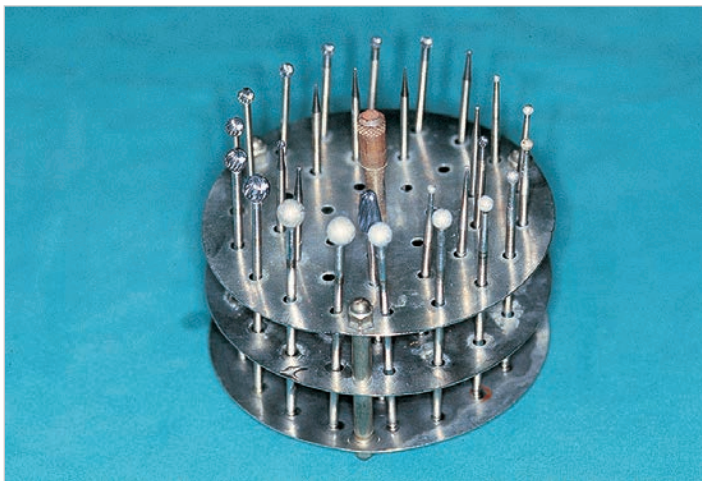


Fig. 3.24 Various burs and a bur stand for microdrills.



Fig. 3.25 Suction tubes with finger control (right). Suction irrigators with finger control (left).

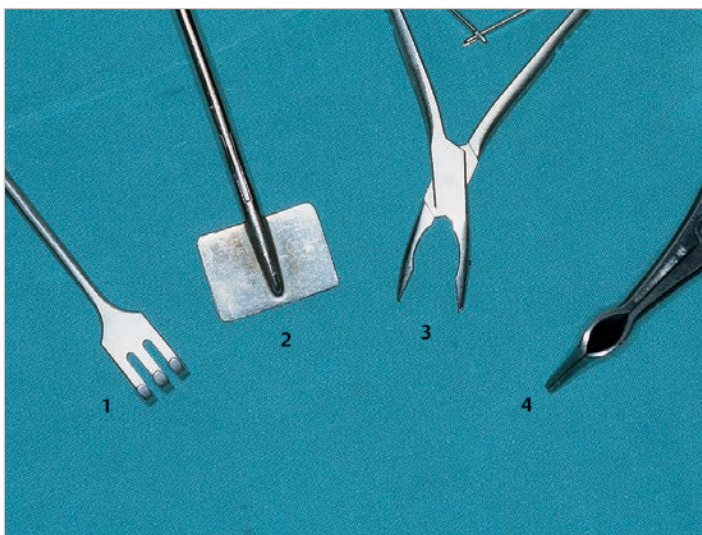


Fig. 3.26 General instruments. 1, skin retractor; 2, fascia press; 3, rongeur; 4, nasal speculum.

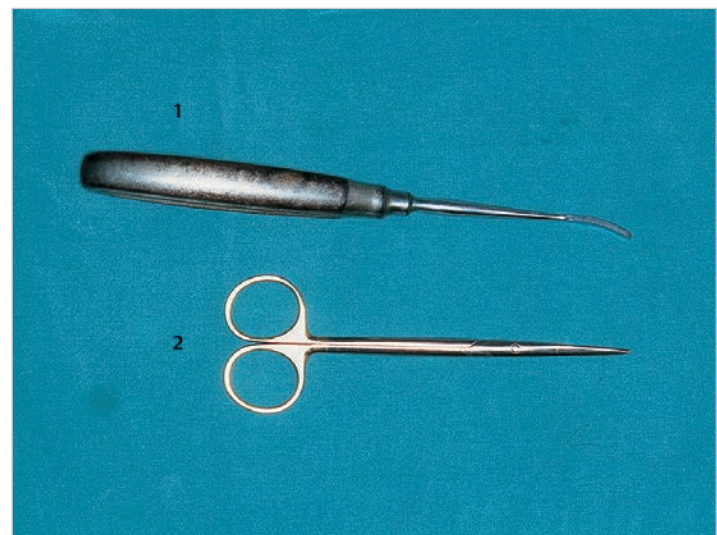


Fig. 3.27 1, lempert periosteum elevator; 2, scissors for graft take.



Fig. 3.28 1, fine forceps; 2, spring scissors; 3, malleus nipper; 4, tympanoplasty scissors.

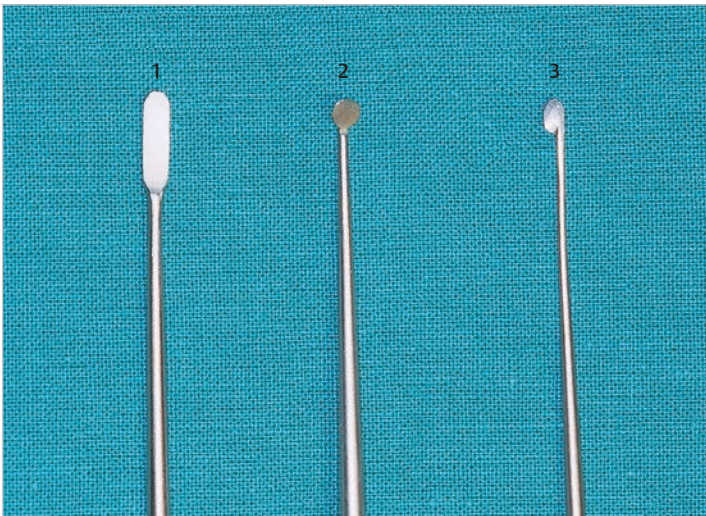


Fig. 3.29 Microdissectors. 1, elevator (#1 [as we call it]); 2, round knife (#2); 3, flap knife (#3).

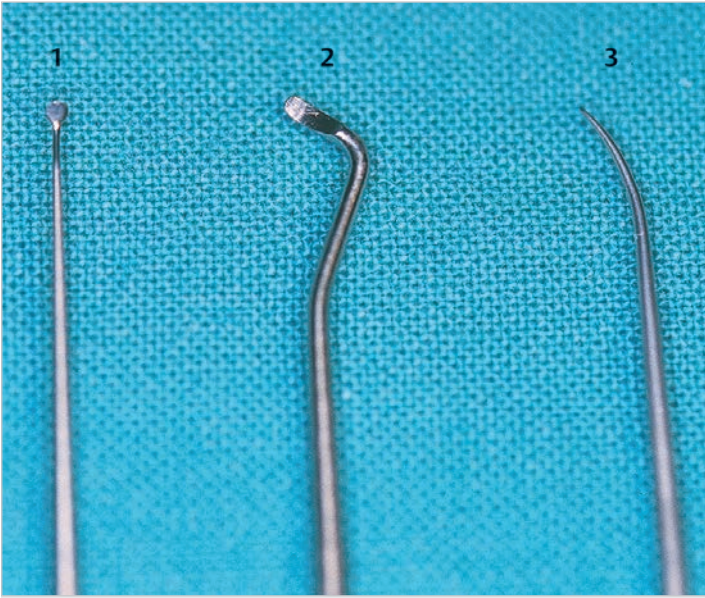


Fig. 3.30 1, micro knife; 2, tympanic sinus hook; 3, needle.

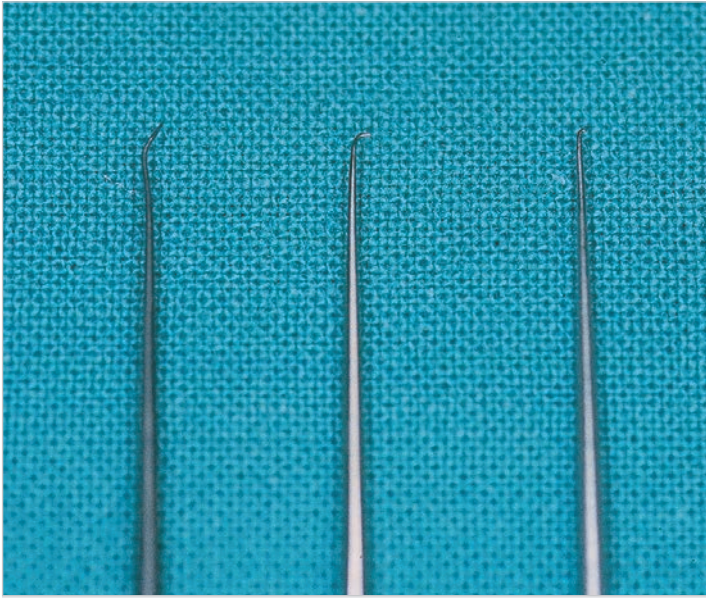


Fig. 3.31 Hooks.



Fig. 3.32 Microforceps and microscissors.

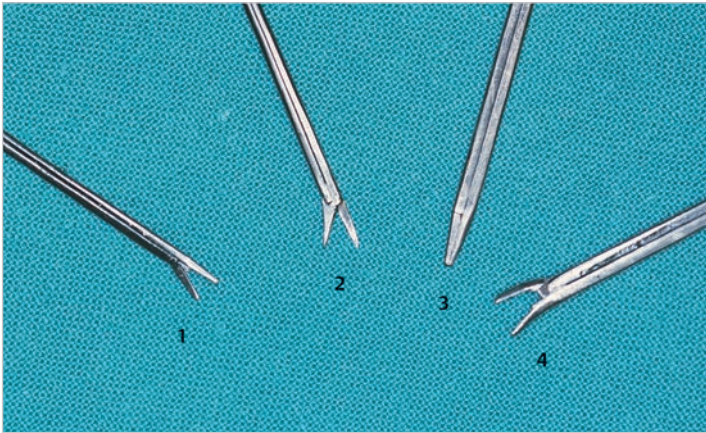


Fig. 3.33 Tip of microinstruments. 1, microforceps; 2, microscissors; 3, self-retaining forceps; 4, crimper forceps.

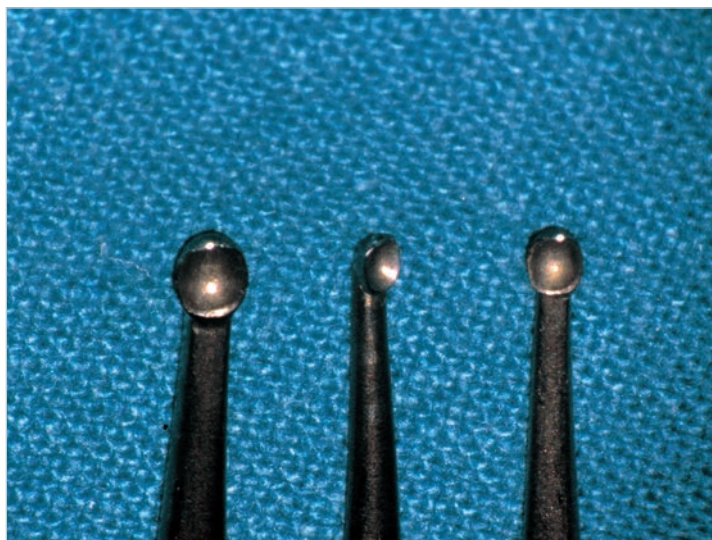


Fig. 3.34 Curettes.

3.1.11 Hints and Pitfalls for Operating Room Setup

- Arrange the operating room for middle ear surgery. Positions of the microscope and the anesthesiologist are the key for that arrangement. For fluent middle ear surgery, the scrub nurse sits in front of the surgeon.
- Patient is placed as comfortable as possible.
- To control the posterosuperior portion of the tympanic cavity where both windows are located, and the facial nerve is protruded, the bed is tilted toward the surgeon, and the head is lowered.
- Head-up position makes control of this area very difficult especially in transcanal approach.
- Position of the surgeon should be comfortable, and the surgeon should be well supported to carry out fine manipulation.
- Hands should be placed as anatomically comfortable as possible.
- Always search for maximum support to the hands holding instruments at any stage. Use surrounding structures and patient's body for that sake. Without support, hands and fingers of human naturally show some tremor.
- Limit the number of the instruments and arrange them in order, always in the same position.
- To concentrate only on the operating field, let the scrub nurse control pedals for drills and coagulators. To be trained, number of nurses involved in the middle ear surgery should be limited.
- Sterilized drapes should cover the surgeon's legs.
- Do not use the facial nerve monitoring if you are not operating anomaly. Instead of that equipment, surgeon should have complete knowledge of anatomy.

3.2 Anesthesia

In middle ear cholesteatoma surgery, type of anesthesia chosen depends on multiple factors such as patients' age, character, general condition, mental situation, and type of surgery. We use local

anesthesia in over 95% of the cases over 14 years old even in open or closed tympanoplasty conducted through retroauricular incision (see ► Fig. 3.35, ► Fig. 3.36, ► Fig. 3.37, ► Fig. 3.38, ► Fig. 3.39). General anesthesia is indicated for such patients as children under 14 years old, adults with extensive scar tissue in the middle ear, mentally intolerable, and who request general anesthesia. In the second stage surgery with minimal invasive procedures, local anesthesia may be used in children under age 14.

3.2.1 Local Anesthesia

Local anesthesia has many advantages in middle ear surgery. It is cost-effective and time-saving in the operating room. Bleeding is reduced, and practically absent. Estimation of hearing and/or facial nerve function during surgery, if required, is possible. In addition, the risk of anesthetic death can be avoided. On the other hand, risks of the local anesthesia such as hypertension, neurogenic shock, and anaphylactic shock do exist, and a surgeon should be well prepared for these situations. We believe it is necessary in the present era to have anesthetist beside the patient even under local anesthesia not only to control pain but also to prepare for possible undesired conditions.

For adults with a weight of 50 to 70 kg, our anesthetists usually prescribe 10 mg of morphine and 50 mg of promethazine. In addition, we use 2.5 mg of midazolam intravenously for sedation just before starting surgery.

To allow infiltration of the solution for maximum effect without losing time, *local anesthesia is applied 10 to 15 minutes before surgery*, prior to sterilization of the operating field and draping. When retroauricular incision is indicated, about 10 mL of the anesthetic solution is injected along with the incision line near the retroauricular fold. From the same region, the needle is advanced anteriorly, and a few milliliters of the anesthetic solution is injected beneath the skin of the external auditory canal. Then, more concentrated anesthetic solution is injected subperiosteally to the canal skin through the canal from four different points, about 1 mL for each, anteriorly, superiorly, posterosuperiorly, and posteroinferiorly. When transcanal approach is indicated, the injection is conducted only in the canal.

The solution for the local anesthesia in the retroauricular region contains the following:

2% lidocaine	30 mL
Distilled water	30 mL
0.1% adrenaline	2 mL

If contraindication due to the patient's general condition, adrenaline is not included in the solution.

For local anesthesia via the external auditory canal, a solution of higher concentration is used. This contains the following:

2% lidocaine	10 mL
0.1% adrenaline	1 mL

After draping, the external auditory canal is widened using a nasal speculum and 1 to 2 mL of the anesthetic solution is injected again, but closer to the tympanic membrane under microscope visualization. This ensures complete pain relief and a bloodless skin incision.

The patient's vital signs such as electronic cardiogram, O₂ saturation, and blood pressure are monitored throughout the surgery.

3.2.2 General Anesthesia

After intubation, subcutaneous injection and sterilization is conducted in the same manner as local anesthesia described above. The only difference is that a solution used in the external auditory canal is the same as the one used in the retroauricular region.

Our anesthesiologists usually use 2 to 2.5 mg/kg of propofol with Tracrium (atracurium besylate) 0.5 mg/kg for induction. The anesthesia is maintained with 40% of O₂ together with 60% of air, and either 2.6% of isoflurane or 6 to 9 mg/kg/h of propofol, together with 12 µg/kg/min of remifentanyl. Extubation is carried out on the operating table.

In such condition that there is no choice other than using nitrous oxide (N₂O), it should be stopped before it disturbs graft placement. The N₂O diffuses through the middle ear mucosa into the middle ear cavity, and may inflate middle ear space and detach graft or replaced skin from underlying bone.



Fig. 3.35 Local anesthesia should be performed before draping, and at least 10 minutes before surgery. Initially, the anesthetic solution is injected in the center of designed retroauricular incision. Then, the needle is advanced anteriorly toward the area just beneath the posterior meatal skin. A few milliliters of the anesthetic solution are injected into the subcutaneous tissue of the posterior wall.

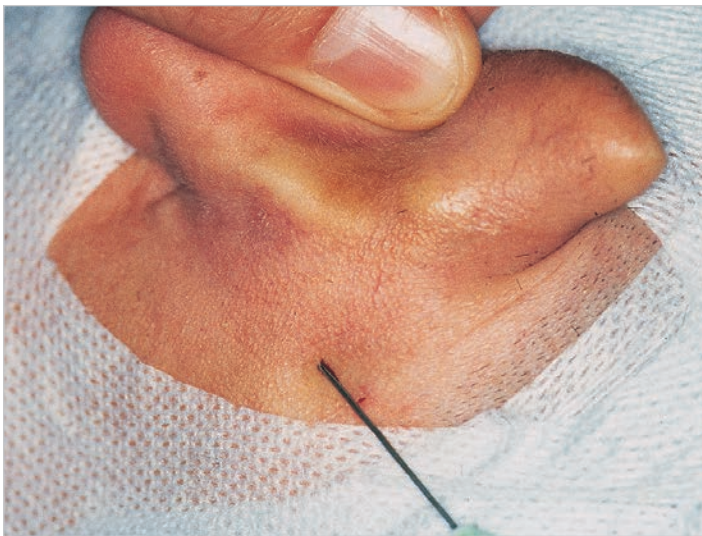


Fig. 3.36 The needle is partially pulled out, but not completely extruded from the initial insertion, and then directed inferiorly to anesthetize that area.



Fig. 3.37 The needle is then advanced superiorly, and the anesthetic solution is injected in that area. It is important to infiltrate the area just above the temporomandibular joint where the auriculotemporal nerve runs. Anesthesia in the retroauricular region is completed.



Fig. 3.38 About 1 mL of anesthetic solution, more concentrated form than used in retroauricular region, is injected subperiosteally at superior wall of the canal. The same procedure is performed in anterior, posterosuperior, and posteroinferior walls.



Fig. 3.39 After draping, the anesthetic is reinforced near the tympanic membrane under microscope. A nasal speculum is used to enlarge the canal.

3.2.3 Hints and Pitfalls for Anesthesia

- Local anesthesia gives many advantages, especially to establish bloodless operating field that allows adequate visualization of structures and handling of the grafting materials.
- Use the anesthetic solution of proper concentration.
- Points of injection are very important.
- To ensure complete infiltration, the anesthetic solution should be injected 10 minutes before starting surgery.
- Insufficient or badly performed local anesthesia causes painful surgery, making patients nervous and less tranquil during surgery.

Transcanal Approach

- Injection is made in four points in the meatus initially, and additional injection is made more medially in the bony meatus under microscope with the help of a nasal speculum.

- When infiltration is successful, the skin appears white because of the vasoconstricting action of the anesthetic.
- The middle ear mucosa can be anesthetized by putting pieces of cottonoid soaked in the anesthetic solution over the required field and wait for a while.

Surgeries via Retroauricular Incision

- Inject the solutions in proper position. Less concentrated solution is injected posteriorly in three points near the retroauricular fold, and the needle is advanced deeply to reach the area beneath the posterior meatal skin. Successful injection in this area makes the posterior meatal skin white.
- The end meatal injections are additionally performed as described above.

In this way, the majority of our cases, excluding children, are operated under local anesthesia.

4 Basic Techniques and Decision Making in Middle Ear Cholesteatoma Surgery

4.1 Basic Techniques for Safe Cholesteatoma Surgery

Since cholesteatoma surgery is a “one-man surgery” working in very complicated temporal bone, intensive practice in the temporal bone dissection laboratory is mandatory before performing any procedure to patients. Temporal bone dissection permits acquisition of perfect knowledge of three-dimensional anatomy of the whole temporal bone. Ideally, the same burrs and drill, suction tips, and set of instruments employed during actual surgery should be used so that the otologist perfects his or her manual dexterity.

Removal of bone with a drill plays key role in cholesteatoma surgery. Establishment of a direct clear view is essential. Make maximum effort to obtain appropriate surgical angle, and prepare your surgical field as bloodless as possible. Do not use sharp instruments, especially cutting burrs, if their tips are not in your view. If there is any doubt during surgery, take your time to review the operating field and anatomical landmarks.

Experienced surgeons usually recognize possible danger in particular situations, and can minimize such risks without thinking. On the other hand, it is difficult for beginners to recognize such risks beforehand. Technical tips for safe surgery are described in the following text.

4.1.1 Drilling

- Bony structures are removed with either curettes or burrs.
- View the aspect to be drilled as perpendicular as possible. Important structures may not be clearly seen and could be damaged if viewed in shallow angle (► Fig. 4.1).

- The handpiece should be held like a pen without covering the superior aspect of the instrument (► Fig. 4.2). Straight handpieces are preferred rather than angled ones for better control. Angled handpieces are used only when the straight handpiece obstructs the view in narrow area (see Chapter 3.1.5).
- The little and ring fingers should be placed on somewhere stable such as patient’s head. This permits precise manipulation of the burr head without trembling.
- The drill should be activated beside the structure to be drilled, and stopped immediately after completing the drilling. Never activate the drill before it is in position and never remove the drill before it stops especially when the burr tip is out of your sight.
- No or minimal pressure should be applied to the burr, especially around important structures. Drilling is usually carried out with the side of the burr rather than the tip for faster bone removal under better view.

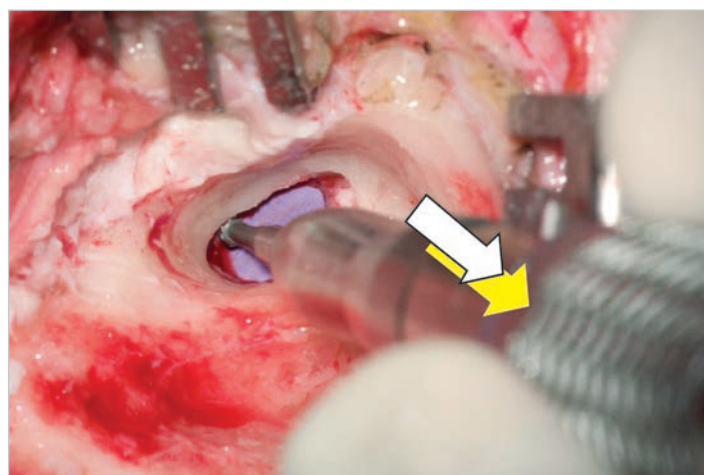


Fig. 4.2 The superior aspect of the handpiece should be kept open (arrow) to see better the area of drilling.

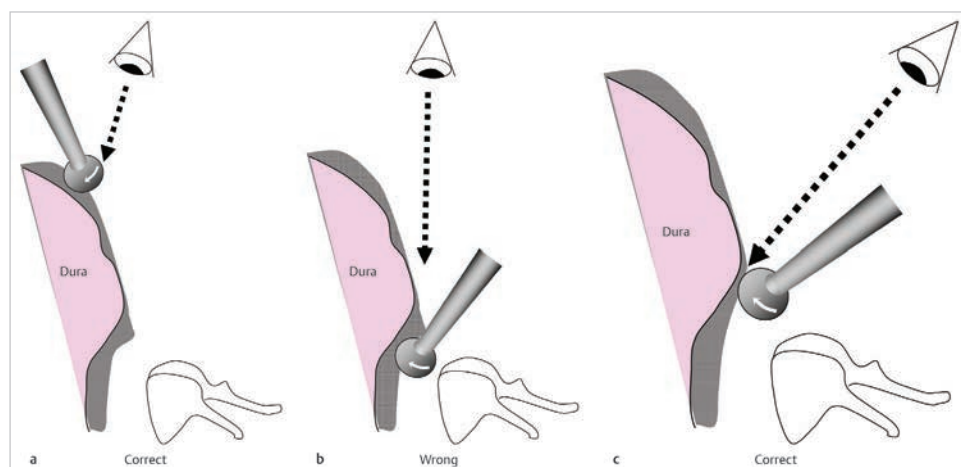


Fig. 4.1 Appropriate visual axis to the dura. The area of drilling should be seen as perpendicularly as possible.

- *Use the largest possible burr.* It allows gradual exposure of wider area that enhances identification of important structures than small burrs. Use small burrs after identifying three-dimensional anatomy of important structures and the area you drill.
- Small burrs, especially cutting, may slip into small bony defect such as exposed fallopian canal (► Fig. 4.3) and may insult its content, especially when some pressure is applied on the burr head.
- Be aware that not only the burr head but also the shaft of the burr can cause severe damage to structures. A fine fiber of connective tissue caught by either the tip or the shaft may suddenly cause catastrophic involvement of entire serial tissue. Such cases are drilling around the meatal skin, the facial nerve, and the chorda tympani (► Fig. 4.4).
- Adjust the length of the burr according to the depth of the area to be drilled. Shorter burrs give better control than longer ones.
- Most part of bone work is done using cutting burrs, because they permit faster bone removal. Diamond burrs are reserved for works near delicate structures such as the facial nerve, the dura, the sigmoid sinus, the jugular bulb, and semicircular canals. Cutting burrs may be used in these areas if you do not compress the burr head toward the structures.
- Hemostasis on the bone is achieved by using diamond burrs pushed toward the bleeding point without irrigation. This technique is essential for *bloodless middle ear surgery*. The heat produced by the diamond burr is sufficient to stop bleeding. Use diamond burrs when the cavity starts bleeding. Thereafter, further bone work can be continued with cutting burrs with minimal risk. In the final step of drilling, diamond burrs serve not only for flattening the surface but also for stopping bleeding.
- Drilling should be started from dangerous areas and end in safer ones. The starting point of the drill track is much more controllable than its end point (► Fig. 4.5). For example, drill medial to lateral in the external auditory canal and the attic when working around the ossicular chain.

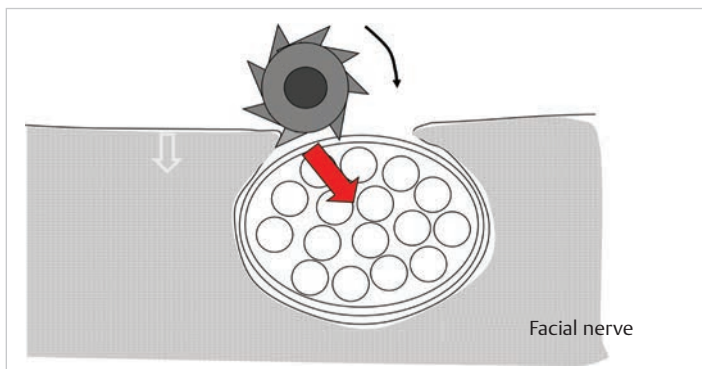


Fig. 4.3 A small cutting burr may slip into vital structures such as the fallopian canal if there is some dehiscence or air cells.

- *Burrs should be moved parallel to the important structures* such as the facial nerve, the sigmoid sinus and the lateral semicircular canal (► Fig. 4.6). This will permit gradual skeletonization of these structures, which increases chance for identification and reduces risks of unpleasant damage.
- Curettes may be the safer choice to avoid accidental inner ear damage when working around the delicate structures such as ossicular chain.
- At the end of surgery, it is very important to wash out bone dust completely from the middle ear by intensive lavage. Remaining bone dust may cause fixation of the ossicular chain to surrounding bony structures.
- When working in very deep areas, precise control of the drill becomes more difficult since the point of support of the drill is away from the tip of the burr. Use of large diamond burrs makes such drilling considerably stable, and is appropriate when working around deep dangerous structures such as the internal auditory canal and the horizontal segment of the carotid artery. Copious irrigation is required to avoid thermal injury.

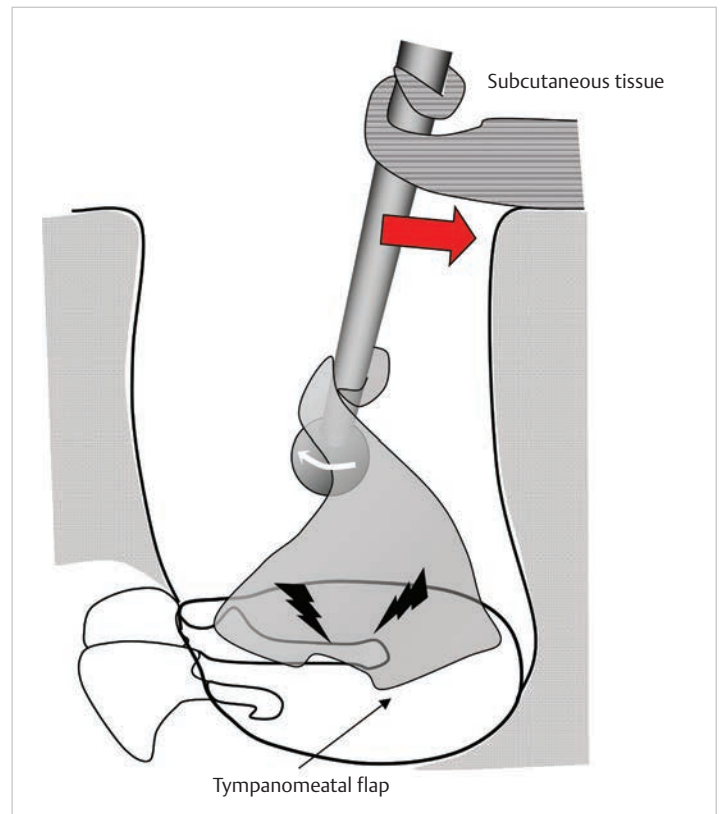


Fig. 4.4 Soft tissue can be involved in the burr, and may cause disaster.

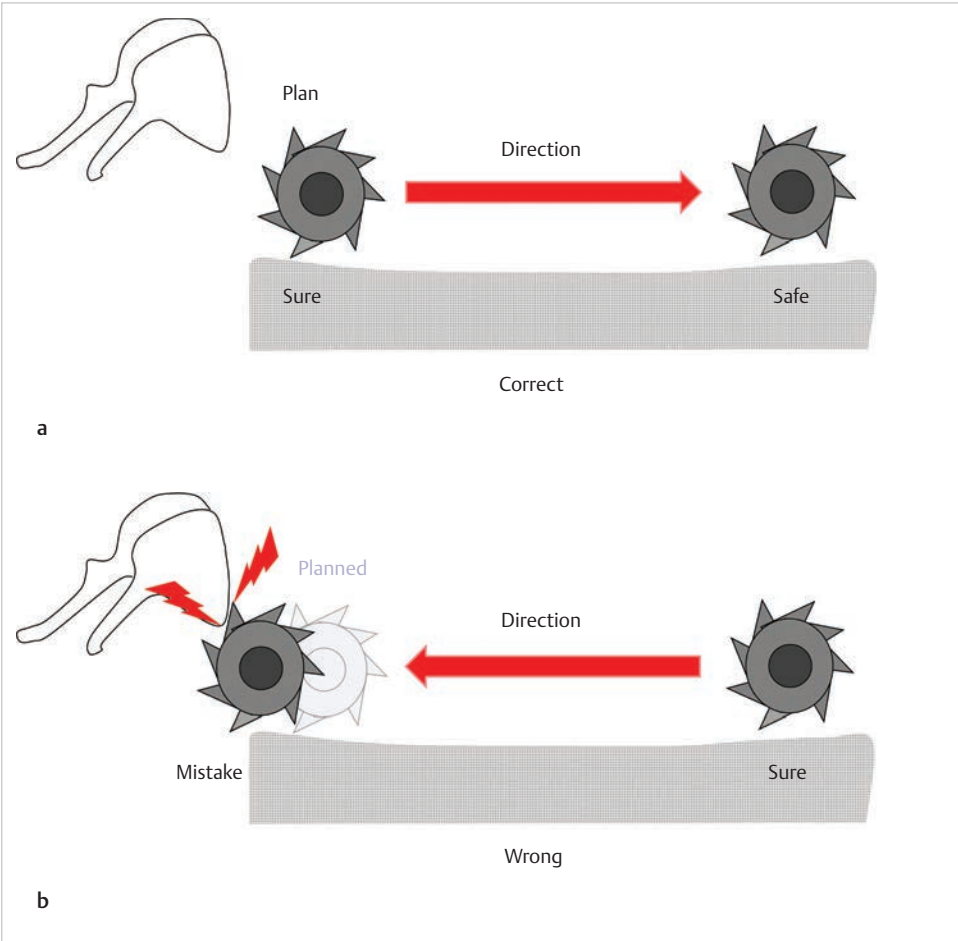


Fig. 4.5 The starting of the drill track can be precise (a), but endpoint is not completely controllable (b).

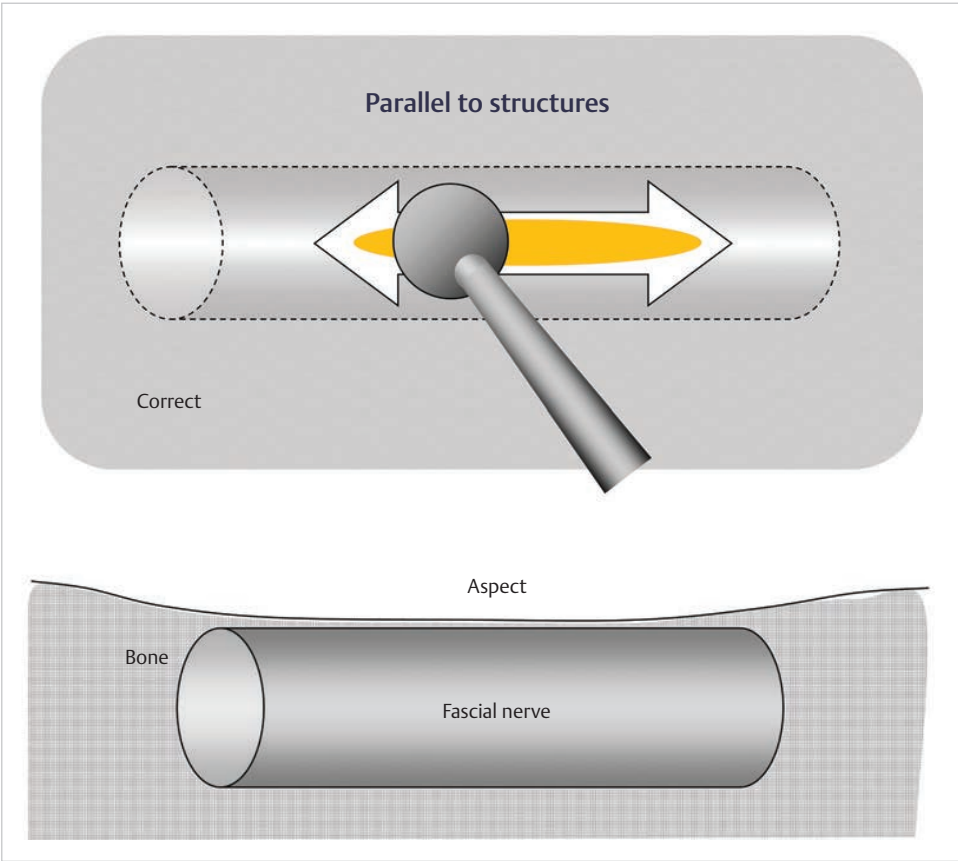


Fig. 4.6 The drill should be moved parallel to the structures for positive identification. Drilling perpendicular to them leads to spot-like exposure that is difficult to notice.

Direction of Drill Tracks (► Fig. 4.7, ► Fig. 4.8)

Parallel to the Structures

1. Middle fossa dura
2. Sigmoid sinus
3. Facial nerve

Medial to Lateral

4. Sinodural angle
5. Attic (around the chain)

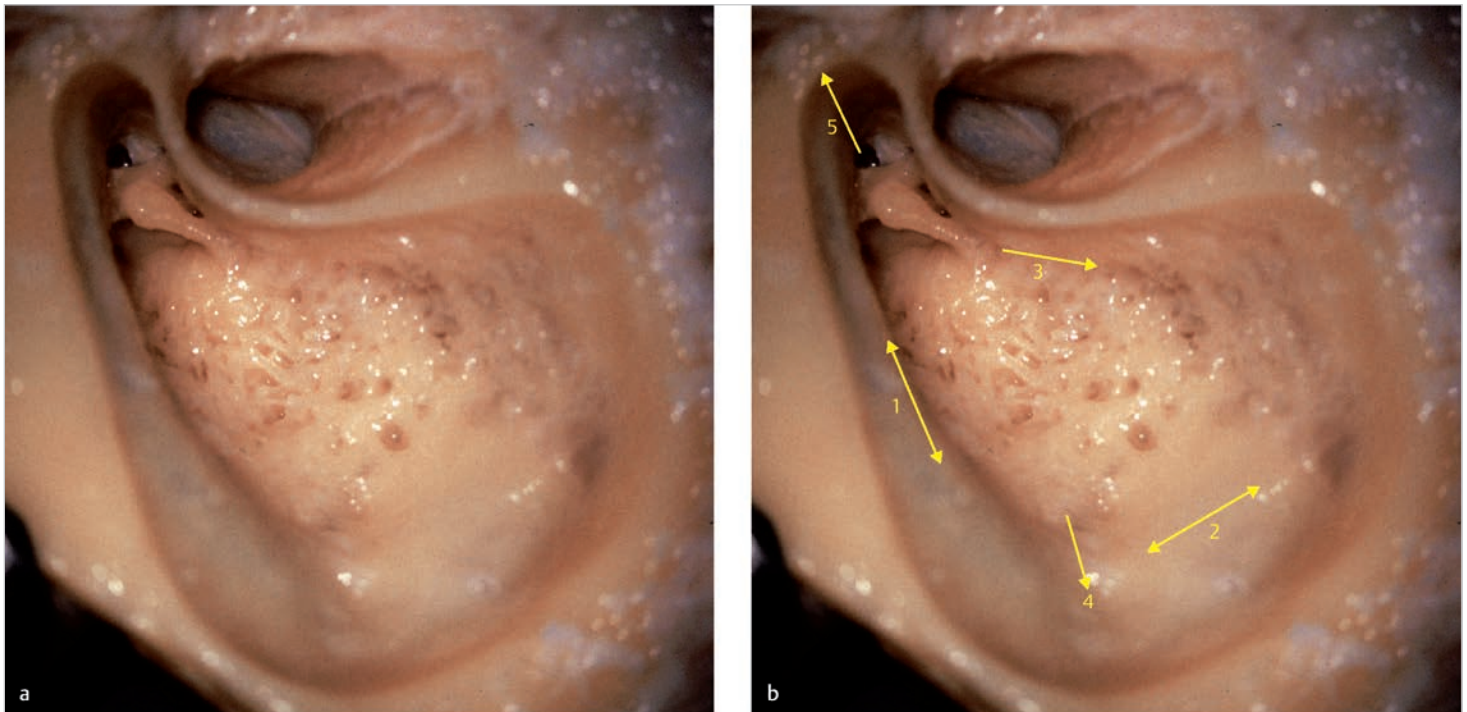


Fig. 4.7 (a, b) Canal wall up cavity in a temporal bone. Here, we have to work around several delicate structures. In the external auditory canal, to avoid injuring the tympanic membrane and the ossicular chain in the bottom of the external auditory canal, the burr head is moved medial to lateral near the tympanic membrane, or parallel to the tympanic membrane. Care should be taken not to touch the lateral process of the malleus. On the middle fossa plate and the sigmoid sinus plate, the burr should be moved parallel to these structures. However, to open the sinodural angle, the burr is moved medial to lateral. In the attic, the burr should be moved medial to lateral, not to touch the ossicular chain. To thin the bone around the area of the facial nerve, the burr should be moved parallel to it, and near the attic, from the chain to inferior (**b**).

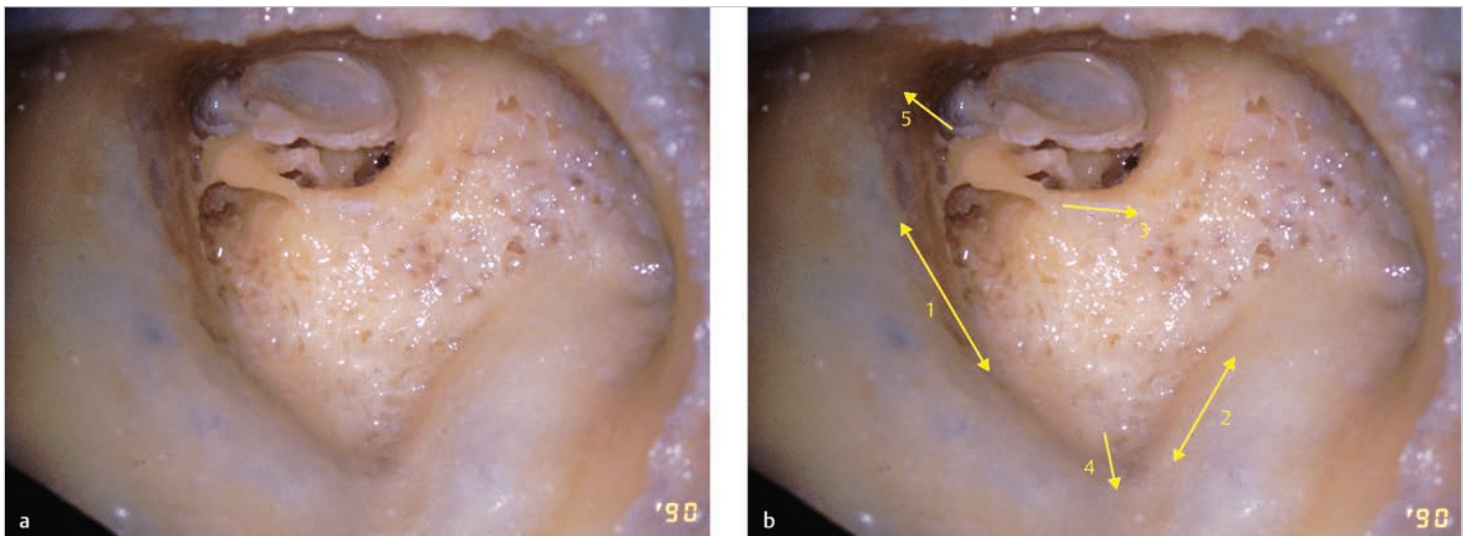


Fig. 4.8 (a, b) Canal wall down cavity in a temporal bone. The same principles are applied to the canal wall down cavity. The difference is the surgeon must skeletonize important structures more intensively to obtain a saucerized cavity (**b**).

4.1.2 Suction and Irrigation

- Suction and irrigation are indispensable in middle ear surgery with bone work. Appropriate suction and irrigation ensure a clear view in the operating field, reduces risk of thermal injury in important structures such as the facial nerve and the labyrinth, and prevents clogging of bone dust between the sharp edges of cutting burrs.
- Accumulated bone dust and blood within and around the operating field are flushed using a 20-mL syringe from time to time during surgery.
- Ample irrigation serves for removal of compiled bone dust and blood with cooling the drilled area. It is indispensable to identify important structures such as facial nerve and blue lining of the semicircular canals.
- The flow rate of irrigation should be changed appropriately when needed. Removal of cortical bone from the mastoid needs much water. In contrast, water should be limited around fine structures and in narrow working spaces. We use an adjustable clamp in the irrigation line and let the scrub nurse control the flow to achieve prompt, adequate control.
- The suction irrigator should wander around the burr during drilling to give sufficient irrigation.
- A useful trick is to place the suction between delicate structures and the burr. It may protect these structures from an accidental hit of the burr. It can also serve as a useful small retractor to keep delicate structures such as meatal skin, sigmoid sinus, and middle cranial fossa dura away from the area of the drilling.
- Suction around delicate structures needs great care; such structures in the middle ear include the meatal skin flap, the chorda tympani nerve, the uncovered facial nerve, and fistula of the labyrinth. Fine suction may be applied either in the vicinity, on a dissector or on cottonoids.
- Brackmann's suction irrigation tips (► Fig. 3.16) are used when working in the cerebellopontine (CP) angle.

4.1.3 Hemostasis

- Never use vasoconstrictors once the dura is opened.
- It is essential for any kind of surgery to obtain satisfactory view of an operating field to avoid surgical complications. Since the middle ear surgery is conducted under the microscope near the very fine, fragile structures in very narrow spaces, small bleeding may impede operator's view causing undesired trouble.
- Hemostasis in soft tissues such as skin and muscles has tremendous importance as an initial step to establish a bloodless, safe operating field. Hemostasis can be achieved with either a monopolar or a bipolar coagulator. Pressure application with an ear speculum or a retractor may stop bleeding. Troublesome oozing that continues after electrocoagulation may be managed with oxidized cellulose (Surgicel).
- Usually, bleeding from bony surface can be controlled by a diamond burr. If significant bleeding does not stop this way, bone wax may be applied with either a finger or a septal dissector. The bone wax may be further compressed by pressure applied on cottonoids.
- Bleeding from mucosa in the tympanic cavity and the tympanomeatal flap may be managed by gelatin sponge or cottonoids soaked in physiological saline with adrenaline and lidocaine (the same solution used for local anesthesia). Leaving these materials on the bleeding point usually stops bleeding after a while. Blocking the opening of the tympanic cavity with these materials simultaneously prevents blood falling down to the cavity. This technique is useful especially before reconstruction, in which bleeding from the tympanic cavity and the tympanic membrane should be stopped completely. During this period, works in another area including preparation of prosthesis,

columella, and the temporalis fascia are conducted so that precious operating time is not lost. Bipolar coagulation in the tympanic cavity is usually avoided whenever possible since thermal injury to the delicate structures nearby may occur.

- The middle and posterior cranial fossa dura and the sigmoid sinus may be exposed during surgery or already uncovered by the disease. Hemostasis in these structures may be achieved with a bipolar coagulator. *Never use monopolar coagulator.* Otherwise, undesired perforation may follow. On the jugular bulb, bipolar coagulation with very low power is required since the structure is very fragile. If hemostasis is not achieved with this procedure, placement of Surgicel on the jugular bulb usually stops bleeding. The Surgicel is left in place (see Chapter 13).
- When working in intradural space, bipolar coagulator is the essential tool for hemostasis. Copious irrigation is important to prevent the tips sticking to the structures coagulated. Tips of the bipolar should be kept clean.
- Gelatin sponge (Gelfoam) is used for the control of capillary ooze and bleeding from small arterioles particularly in those locations where the bipolar can be injurious. The material can be left in place even in CP angle.
- Oxidized cellulose (Surgicel) functions as artificial clot, and is mainly used to stop capillary ooze in the CP angle. This is potentially useful at the level of cerebellum, where diffuse venous bleeding may occur.
- Surgicel is effective to stop bleeding from brainstem. Use of bipolar on brainstem has potential risk of coagulating perforating arteries that will cause infarction.

4.1.4 Dissection

- A delicate blunt dissection over bony structures and in remnant air cells may be carried out with a small cottonoid placed on a plane of cleavage between the pathology and the bone. The cottonoid is gently pushed with a microraspatory and a suction tip. This technique concurrently absorbs blood and reduces bleeding by applying pressure without disrupting the pathology. Indirect suction on the cottonoid clears the view. The technique is useful especially in dissection of cholesteatoma matrix, and is used when elevating tympanomeatal flap from the bony meatus.
- A sharp dissection and debulking of the pathology should be carried out around the delicate structures such as the ossicular chain, the oval and the round windows, the facial nerve, and the labyrinthine fistula. Debulking of the pathology increases the surgical angle, clears the view around these structures and helps to establish a plane of cleavage. Excessive trial to remove bulky pathology near these structures may cause serious damage if some adhesion exists.
- Careless elevation of the pathology from the bone is also prohibited. In case of cholesteatoma, *always suspect existence of a labyrinthine fistula*, especially near the lateral semicircular canal. In some cases, the matrix should be left over the fistula not to open the labyrinth. Inflamed facial nerve may look like granulation tissue.
- Dissection of some pathology from the stapes requires great care. Instruments need to be moved in parallel to the stapedia tendon, in the direction from posterior to anterior, especially when the incudostapedial joint is dislocated. The superstructure is more resistant in this way, supported by the tendon. Sharp dissection is preferable to blunt dissection. Excessive force perpendicular to the long axis of the footplate may cause fracture or disarticulation of the stapes.
- *Use parallel movement to the facial nerve* when some pathology on the nerve needs to be dissected. Never use hooks, since it may damage the nerve.

- Once the CP angle is opened, direct contact between the instruments and the brain surface should be avoided. Mero-cel (polyvinyl acetal polymer) is applied over the brain surface to afford protection. Mero-cel can also act as a dissector if it is gently inserted between cholesteatoma and brain tissue.

4.2 Decision Making in Middle Ear Cholesteatoma Surgery

4.2.1 Who Should Be Operated?

Therapeutic strategy of cholesteatoma should be planned considering its invasive and progressive nature. Surgery may be suspended only in limited elderly cases if it does not contain debris, and close follow-up of the patient is possible. Cholesteatomas with debris in inaccessible areas, active inflammation, apparent growth, and potential risk of life-threatening condition should be treated surgically. Optimistic follow-up in such cases with simple cleaning of the debris around the orifice of cholesteatoma usually risks that ear, resulting in necessity of larger surgery with higher rate of surgical complications. Of course, patient's wishes, age, and health are the factors to be concerned, and the surgeon should know fully the natural history of each disease and validity of the surgical intervention in these circumstances. After all these factors have been considered, the surgery should be planned with the patient's fully informed consent.

4.2.2 Strategy in Only Hearing Ear

In general, the only hearing ear should be operated only when possible risk of hearing loss for disease surpasses the one for surgery. Since cholesteatoma may eventually cause a labyrinthine fistula followed by irreversible labyrinthitis and deafness, optimistic follow-up without correctly evaluating status of cholesteatoma is strictly prohibited. If surgery is required, it needs to be emphasized that the surgery must be performed only by a very experienced surgeon. Any kind of surgical intervention may cause irreversible sensorineural hearing loss, and failure of the surgery simply increases the risk. Avoid drilling whenever possible. Using a curette for bone removal around the ossicular chain is a safer choice regarding the risk of inner ear damage.

Canal wall down technique is almost always indicated according to our strategy. The reason is that this technique, if properly performed, offers better chance of eradicating the pathology without any particular sequelae, and thus minimizes the risk of recurrence. Further surgical interventions, with their potential risk even in the most experienced hands, may therefore be avoided. The modified Bondy technique is preferred if there is no pathology in mesotympanum and hypotympanum since this surgery does not damage the ossicular chain. If there is cholesteatoma matrix on either the oval window or the round window, radical mastoidectomy is performed to exteriorize it and to avoid possible risk to open the inner ear. In such cases, the eustachian tube is obliterated to avoid chronic suppuration that may cause sensorineural deterioration of the hearing loss.

4.2.3 Staging Strategy

The surgeon needs to preplan the surgery after correctly evaluating status of cholesteatoma and anticipating its clinical course. The

possibility or necessity of the second stage operation should be discussed with the patient before performing the first surgery. We generally stage the cholesteatoma surgery in both canal wall down and canal wall up tympanoplasties. The second stage operation is planned within a year to verify eradication of cholesteatoma and to reconstruct the sound transmission system. In limited cases in which modified Bondy technique is used and risk for recurrent or residual cholesteatoma is considered very low, we do not plan the second stage. If there is a cholesteatoma tightly adhering to delicate structures such as the stapes (either the footplate or the superstructure), the round window and the facial nerve, we generally leave the matrix on these structures. Excessive maneuver on the stapes or the round window may cause labyrinthine fistula, and excessive maneuver on facial nerve may damage it. Removal of the matrix is easier and safer choice in noninflamed, aseptic condition during the second stage. The matrix may evolve like a pearl in the second stage. We apply the same rule to the matrix left over the labyrinthine fistula in the closed cavity.

When we intentionally leave cholesteatoma matrix in the tympanic cavity such as area of the windows, the second stage operation is planned within 6 months after surgery. If we doubt complete removal of the cholesteatoma from the middle ear, we plan the second stage operation earlier than 1 year, usually 8 to 10 months after surgery. The second stage is usually less invasive, and can be finished in shorter time. If the mastoid is not involved in cholesteatoma, it can be performed via transcanal approach under an ear speculum in most of the cases. Minimal, if any, hospitalization is necessary. Patients usually will accept to have staged operation if they are informed its benefit and/or risk of the disease.

4.2.4 Strategy for Revision Surgery

Revision surgeries are planned when cholesteatoma recurs, when functional problems appear in reconstructed ossicular chain and/or tympanic membrane, and when inflammation remains after canal wall down tympanoplasty. Revision surgeries are always much more difficult than the first surgery. The anatomy of the middle ear may be changed in the revision. Some of the important landmarks may be lost, and fragile structures may be exposed. The middle ear structures may be scarred and/or may have become more fragile by the previous traumatic intervention. Since techniques executed for appropriate correction in such situation should be individualized, considerable knowledge and surgical skills are required.

Incorrect and unskilled techniques used in the former surgery are the major causes of the revision surgeries. However, in some cases, the developed problem is a manifestation of underlying dysfunction, and may be an indication of ineffectiveness of the surgical philosophy of the former surgery, or even surgical intervention itself. Another similar surgery may simply result in the same sequelae. The surgeon should have a high mental elasticity, full range of knowledge, and surgical skills to deal with such cases.

If cholesteatoma recurs after canal wall up tympanoplasty, we generally transform the cavity into open. If revision ossiculoplasty is required after closed tympanoplasty, we inspect the cavity to make sure there is no cholesteatoma. In revision surgery for inflamed canal wall down cavity, the shape of the cavity is corrected, air cells are removed sufficiently, and meatoplasty is performed.

5 Retroauricular Transcanal Approach

According to our strategy, a transcanal approach through retroauricular incision can be used only in limited cases of cholesteatoma. To prevent recurrence of the cholesteatoma, we believe that it is important to maintain bony wall as much as possible when canal wall down technique is not used. Therefore, we do not pursue distal end of cholesteatoma by removing the posterior wall widely from the bony meatus. The use of this approach in our group is therefore limited only to the cases with small pars tensa cholesteatomas with minimal invagination into the attic and the facial recess, or congenital cholesteatomas mainly localized in the tympanic cavity. Since a wide external auditory canal is a prerequisite of the safe surgery, technique to carry out appropriate meatoplasty safely is of tremendous importance. The

bone removed in the surgery to enlarge the approach to the cholesteatoma should be securely closed using a sufficiently large piece of cartilage. If there is a necessity to enlarge the approach, or the matrix is disrupted in invisible area from the small atticotomy, we convert the technique to canal wall up to ensure eradication of the disease under the preserved canal wall. Refer to the case presented in this chapter (see ▶ Fig. 5.1, ▶ Fig. 5.2, ▶ Fig. 5.3, ▶ Fig. 5.4, ▶ Fig. 5.6, ▶ Fig. 5.7, ▶ Fig. 5.8, ▶ Fig. 5.9, ▶ Fig. 5.10, ▶ Fig. 5.11, ▶ Fig. 5.12, ▶ Fig. 5.13, ▶ Fig. 5.14, ▶ Fig. 5.15, ▶ Fig. 5.16, ▶ Fig. 5.17). Additional cases are also shown in Chapter 8.

Case 5.1 (Right Ear)

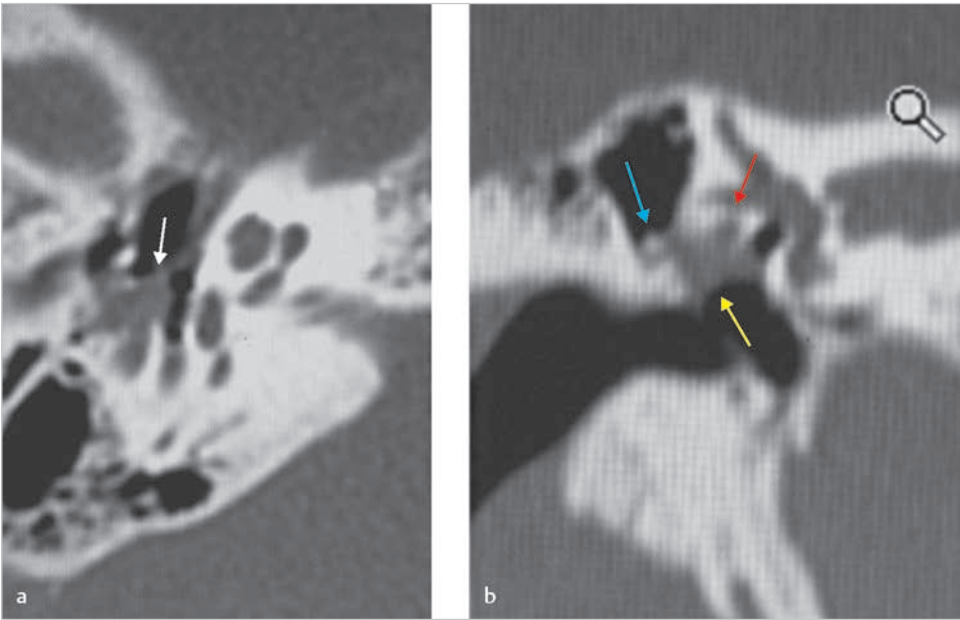


Fig. 5.1 The axial computed tomography (CT) (a) demonstrates limited extension of the cholesteatoma to the posterosuperior part of the tympanic cavity. An erosion of the incudostapedial joint is identified (arrow), The coronal CT (b) demonstrates small extension of the cholesteatoma superiorly to the tympanic segment of the facial nerve (red arrow), but it does not surpass the short process of the incus (blue arrow).

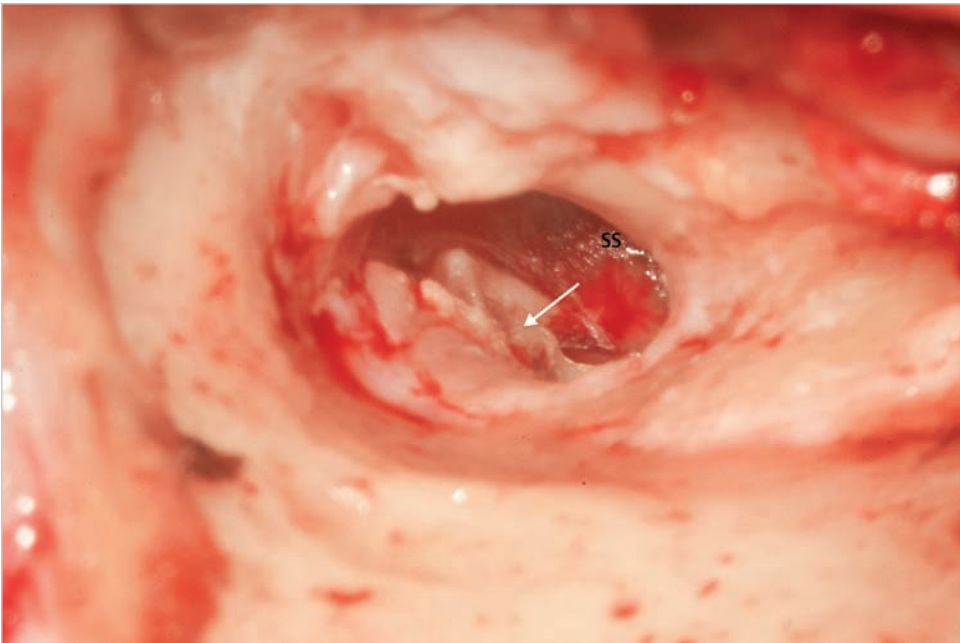


Fig. 5.2 The meatus is entered through a retroauricular incision. A pars tensa cholesteatoma is identified in the posterosuperior quadrant of the tympanic membrane (arrow). Access to the tympanic membrane is limited by bony protrusions in the anterior and the inferior walls. SS, sigmoid sinus.

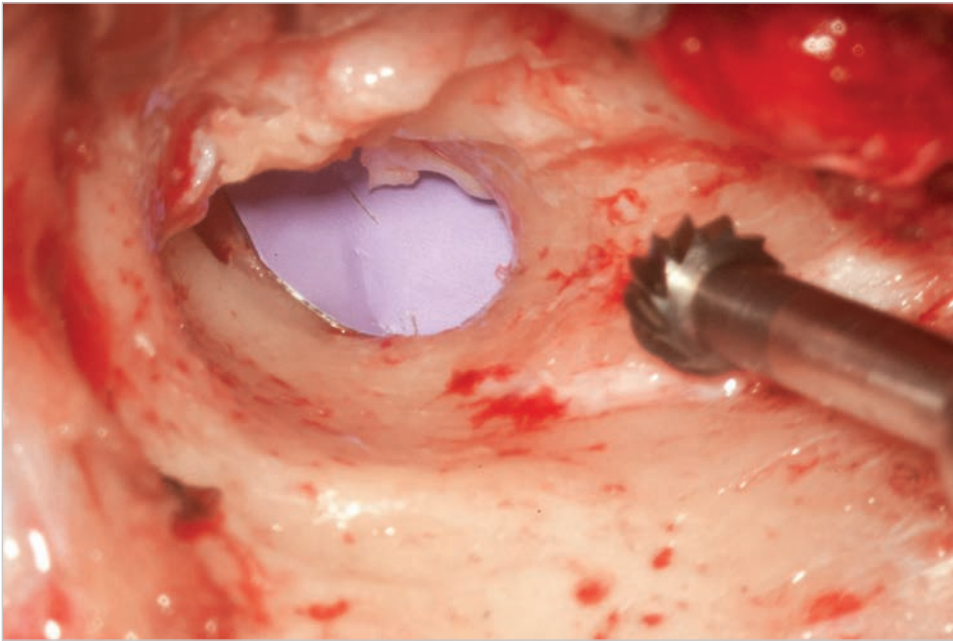


Fig. 5.3 The whole skin in the external auditory canal is detached medially, and the bony meatus is ready for canaloplasty. To save time, the largest possible burrs are used in this procedure. Since cutting burrs easily catch the tympanomeatal flap, the flap should be protected with an aluminum sheet made from the cover of surgical thread.

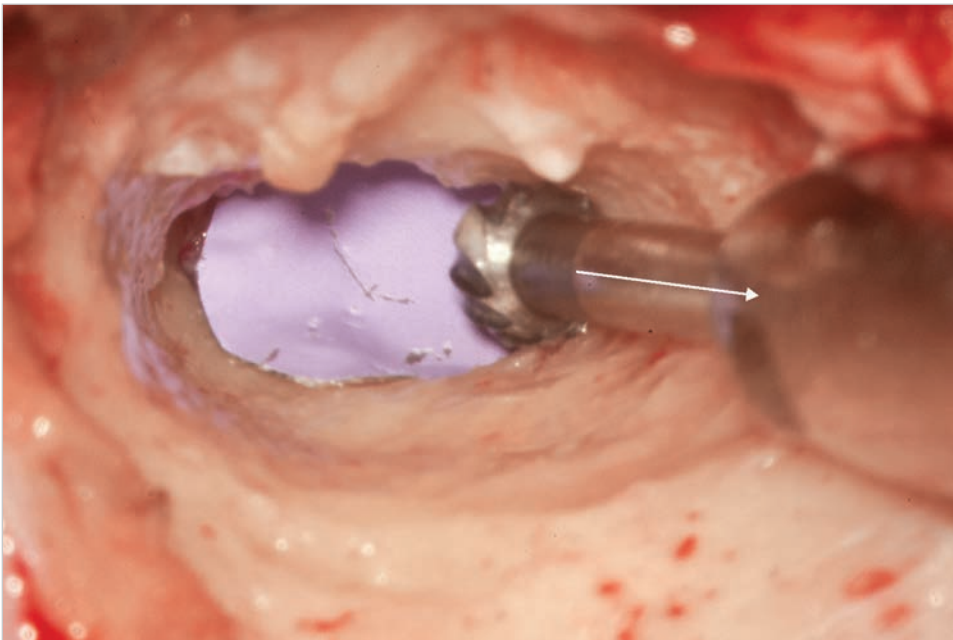


Fig. 5.4 Canaloplasty is on the way. In canaloplasty, never move the drill from lateral to medial. The drill should be moved from medial to lateral in the superior and the inferior walls (arrow), and parallel in the anterior and the posterior walls.

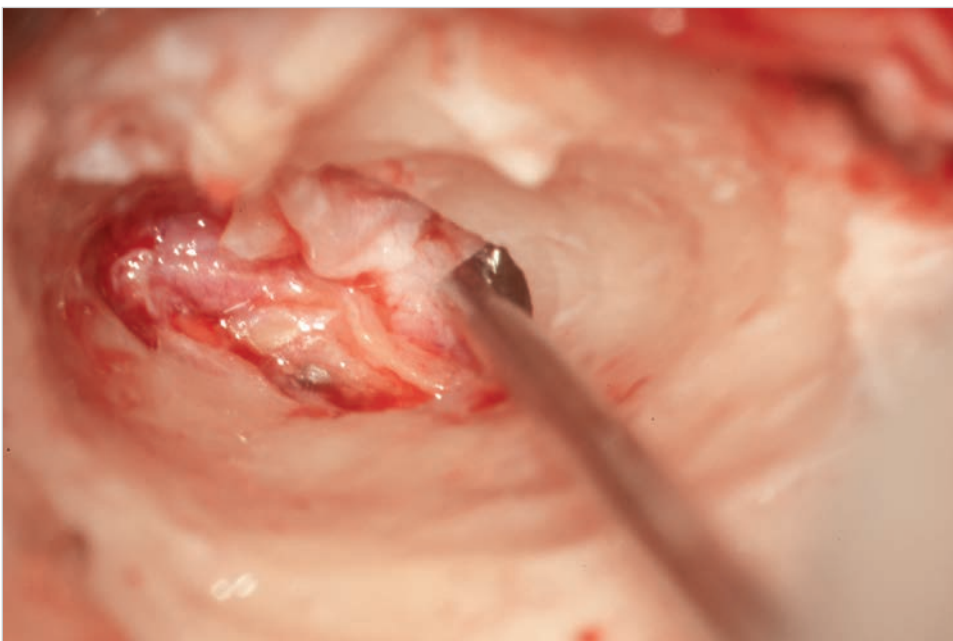


Fig. 5.5 Removal of the bony protrusion to some extent enables dissection of the meatal skin from the bone located medially to the drilled area. The drilling of the meatus is gradually advanced medially by repeating such process.

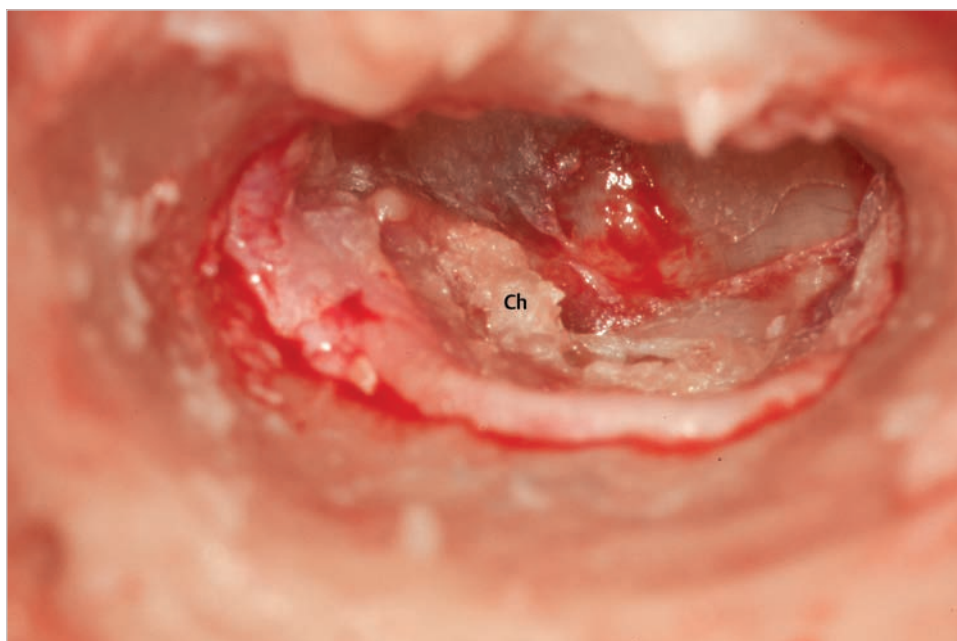


Fig. 5.6 Canaloplasty is accomplished. Note that the entire tympanic membrane has become accessible. Ch, cholesteatoma.

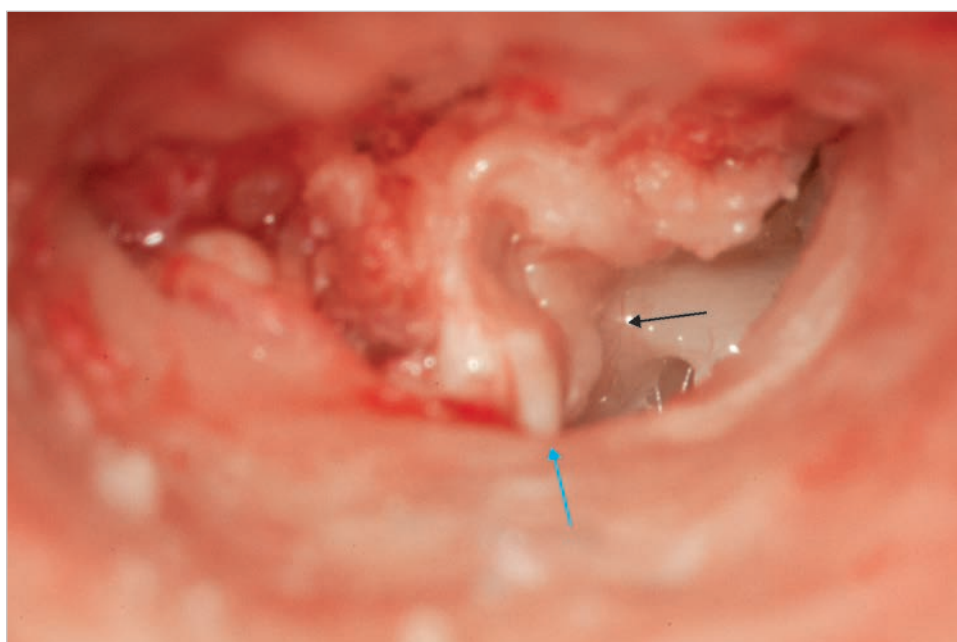


Fig. 5.7 The tympanic cavity is entered from inferior not to damage the matrix of cholesteatoma. The inferior pole of the cholesteatoma is visualized (*black arrow*). The chorda tympani nerve involved in the cholesteatoma is seen (*blue arrow*).



Fig. 5.8 The chorda tympani nerve is cut, and the matrix is carefully detached from the surrounding bony structures.

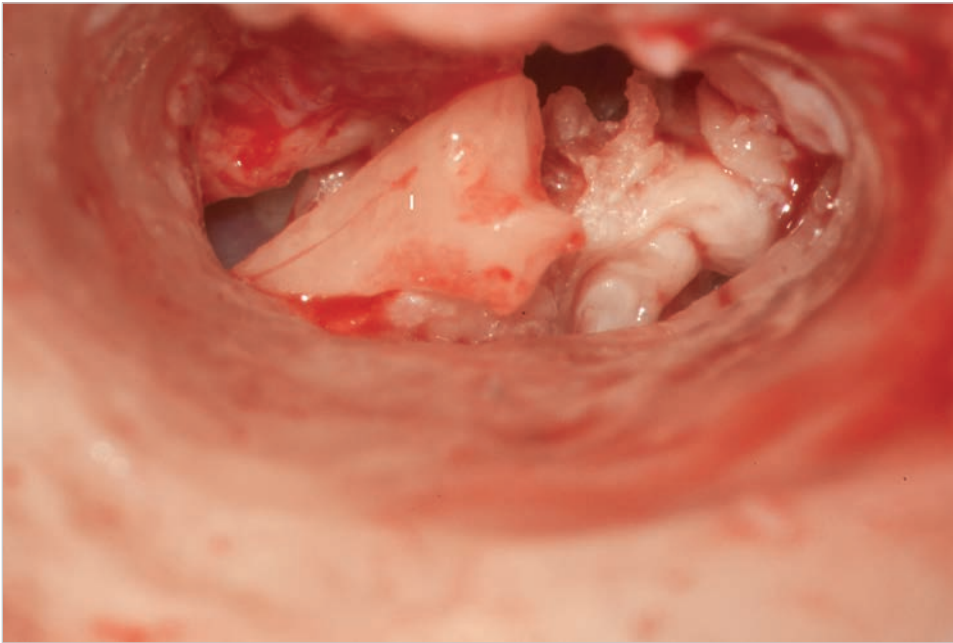


Fig. 5.9 The remnant of the incus covering the cholesteatoma is removed. Note the erosion of the long process. I, incus.



Fig. 5.10 Since the cholesteatoma has eroded the posterosuperior part of the bony annulus, removal of the incus visualized the superior pole of the cholesteatoma. CP, cochleariform process; FN, facial nerve; S, stapes.

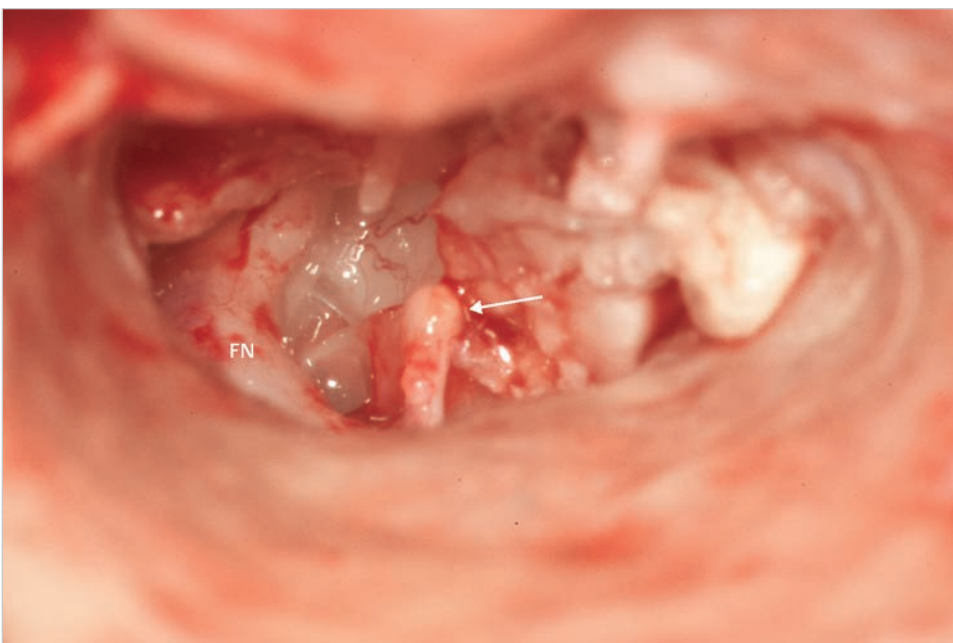


Fig. 5.11 The cholesteatoma is detached from the superstructure of the stapes (*arrow*). FN, facial nerve.

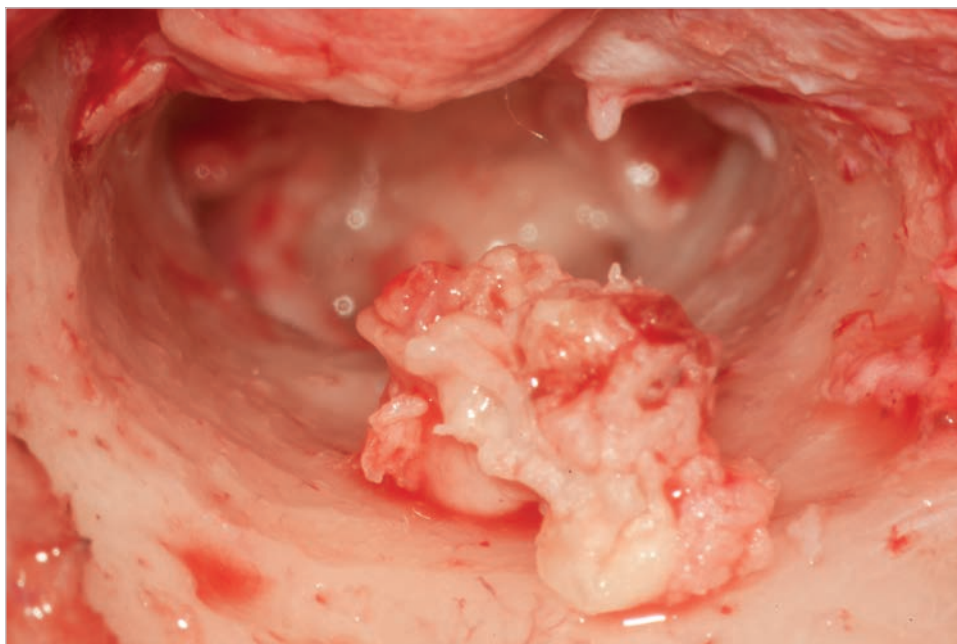


Fig. 5.12 The cholesteatoma is eradicated from the middle ear. The matrix is completely preserved.

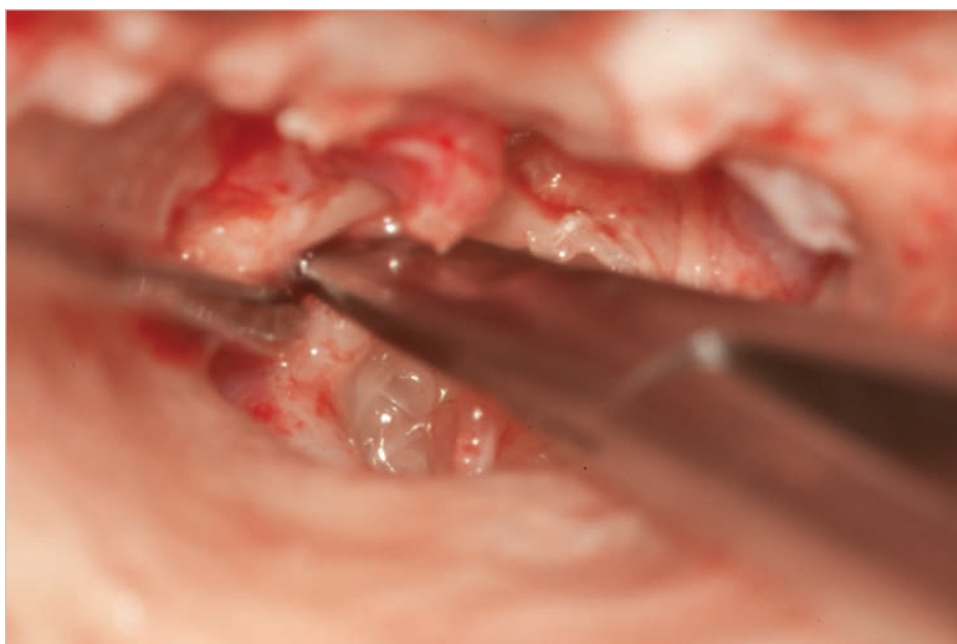


Fig. 5.13 The tendon of the tensor tympani muscle is cut to mobilize the medialized tympanic membrane.

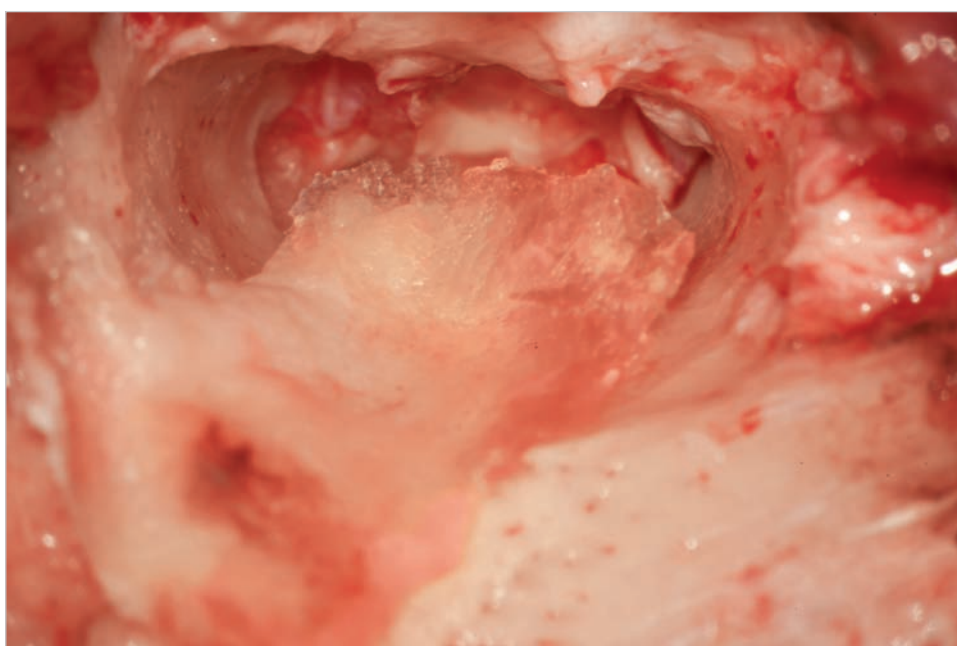


Fig. 5.14 A piece of temporalis fascia is introduced into the canal.

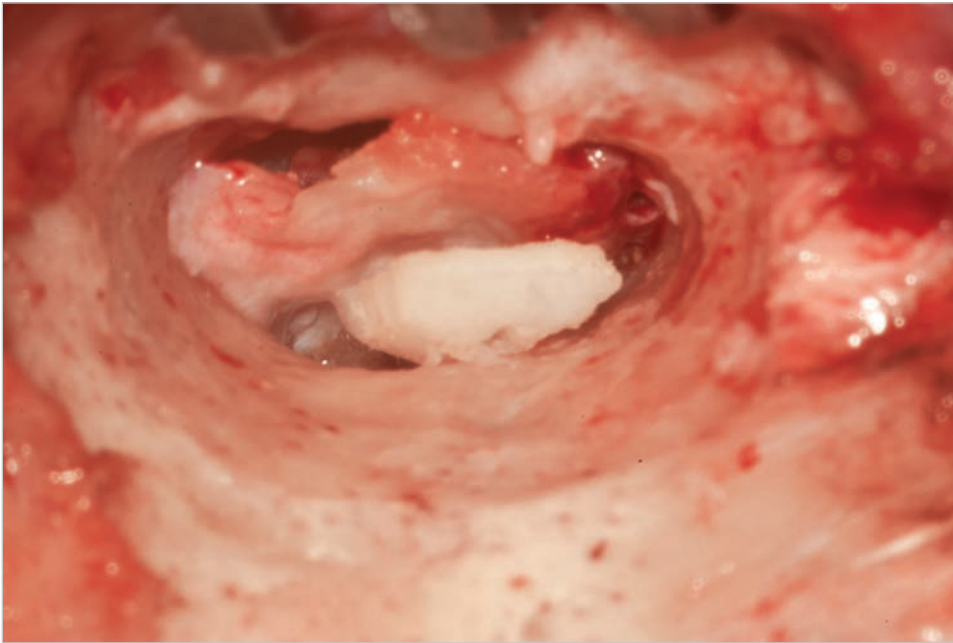


Fig. 5.15 The fascia is grafted underlay. After partially packing the tympanic cavity with Gelfoam, a piece of thick tragal cartilage serving for reinforcement of the posterosuperior quadrant of the tympanic membrane, and simultaneously, as a columella is introduced.



Fig. 5.16 The cartilage is placed over the stapes.

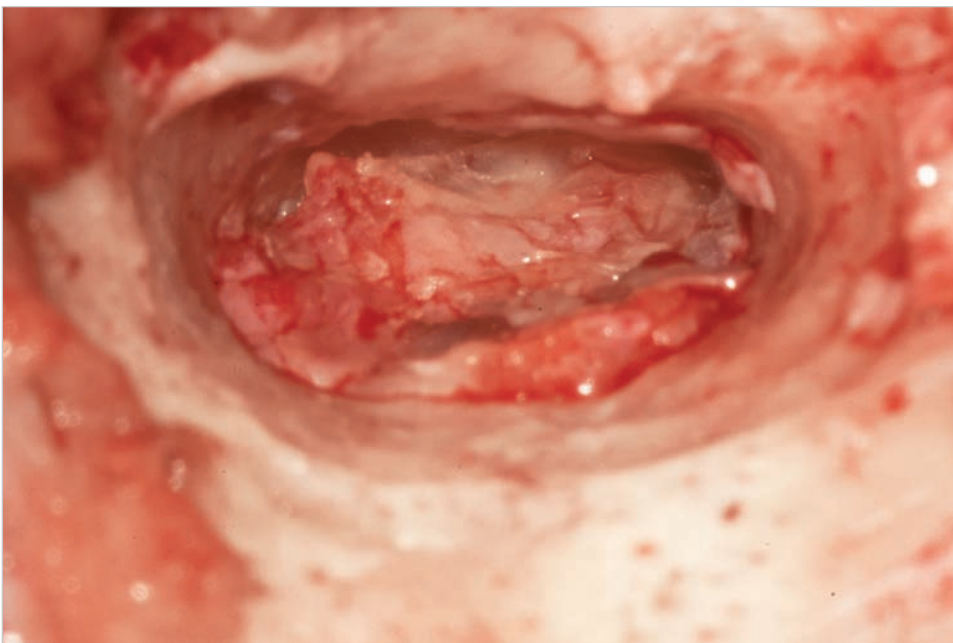


Fig. 5.17 The tympanomeatal flap is replaced over the fascia, and the tympanoplasty is completed.

6 Canal Wall Up Tympanoplasty

Indications

- Following are the indications for canal wall up tympanoplasty:
- Cholesteatoma in children and in patients with highly pneumatized mastoids.
 - Minor epitympanic erosion.
 - Mesotympanic cholesteatoma.

There is no single procedure to treat all cases of cholesteatoma. The surgeon should be flexible and well prepared to choose a surgical technique suitable for the particular patient. Whenever a minor epitympanic erosion is present, we adopt a canal wall up (CWU) (closed) technique with reconstruction of the attic using cartilage and bone paste. In general, we use canal wall down (CWD) (open) tympanoplasty in most cases of cholesteatoma, since CWU technique results in higher residual (► Fig. 6.1) and recurrent (► Fig. 6.2) rate compared to the CWD technique. Surgical intervention for cholesteatoma using CWU tympanoplasty should be completed by the second-stage operation, since the objective of the surgery is not only to reconstruct the sound transmission system, but also to eradicate any residual cholesteatoma. Currently, we use closed technique only in selected cases.

In patients with highly pneumatized mastoid, CWU tympanoplasty is also indicated to avoid having a very large cavity. In children, we try to perform a staged CWU tympanoplasty because of their highly cellular mastoids and in an attempt to preserve the anatomy of the ear as much as possible. However, even in such cases, if there is large epitympanic erosion or surgery reveals intensive involvement of the middle ear by cholesteatoma, we use the CWD technique. CWD tympanoplasty is also chosen for the only hearing ear. In the presence of mesotympanic cholesteatoma, especially in

young patients, closed tympanoplasty may be indicated. In the first operation, a CWU tympanoplasty is performed with reconstruction of the tympanic membrane, and a Silastic sheet is placed through a posterior tympanotomy toward the eustachian tube to cover both the tympanic cavity and the mastoid. Silastic favors regeneration of the middle ear mucosa and prevents the formation of adhesions. However, if the posterior wall interferes with the view of the cholesteatoma matrix, for example, by extension toward the eustachian tube, open tympanoplasty is adopted, especially in old patients.

If the surgeon is not sure whether removal of the posterior canal wall is suitable, every surgical step is performed as CWU tympanoplasty. Once it turns out that CWD tympanoplasty is indicated, conversion of the technique by removing the posterior wall is not a major effort. Time spent in canalplasty and tympanotomies is worthwhile for the patient.

In the second stage, usually performed 8 to 12 months later, the middle ear is checked for eradication of any residual cholesteatoma. The approach for the second stage is transmeatal, transcanal, or transmastoid, depending on the localization of the cholesteatoma and approach used in primary surgery. If a recurrent cholesteatoma or absorption of the posterior canal wall is encountered in the second stage, we transform the technique into CWD without hesitation.

Postoperatively, regular otoscopic follow-up, for at least 10 years, is essential to identify the formation of a retraction pocket or recurrent cholesteatoma. If these occur, there should be no hesitation in switching to a CWD tympanoplasty, since we believe that they indicate a persistent underlying pathology, even after the earlier CWU tympanoplasty.

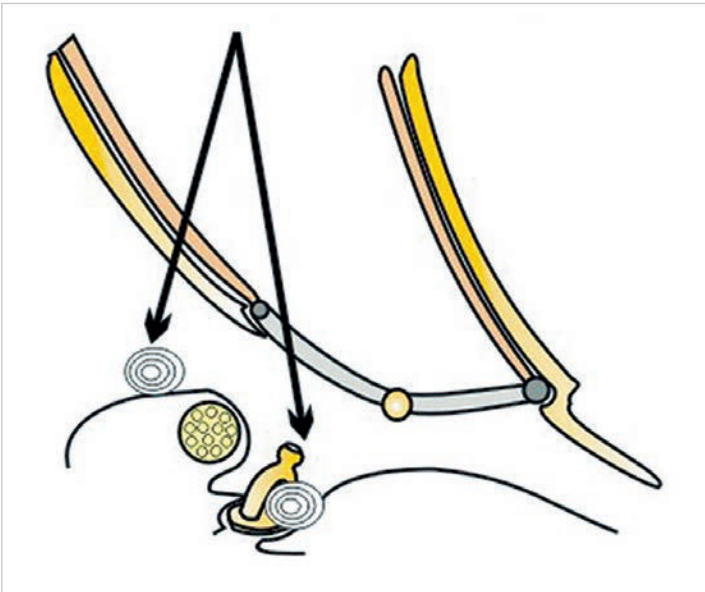


Fig. 6.1 Residual cholesteatoma.

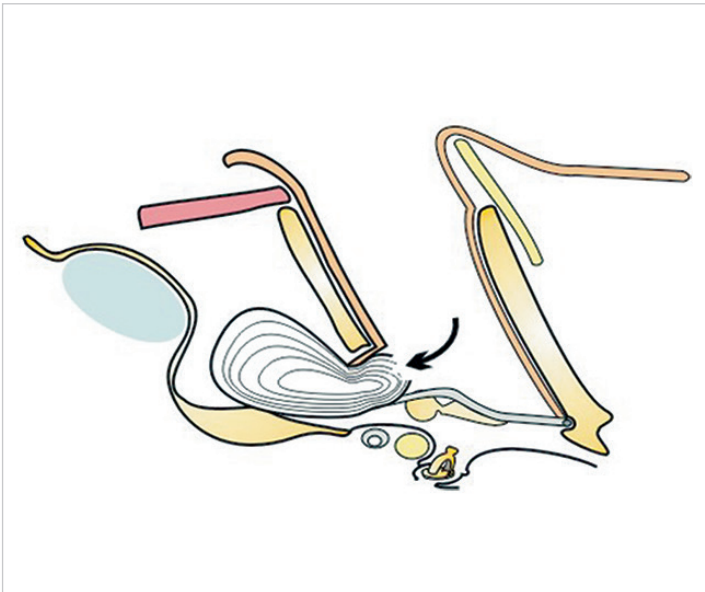


Fig. 6.2 Recurrent cholesteatoma.

6.1 Surgical Steps

6.1.1 Simple Mastoidectomy

1. The technique used for mastoidectomy in CWU tympanoplasty should be the same as CWD tympanoplasty. The only difference from the CWD technique is a preservation of posterior canal wall. *Adequate saucerization of the mastoid cavity* with complete drilling of the sinodural angle and bony overhang at cavity edges should be carried out before posterior epitympanotomy and posterior tympanotomy is performed. The saucerized cavity gives the maximum surgical view and surgical angle (► Fig. 6.3, ► Fig. 6.4). Canalplasty is required whenever the canal wall impedes a complete view of the tympanic membrane. Therefore, the canal wall should not be thinned from the beginning.
2. The meatal skin flap is elevated medially and the canalplasty is performed. For better control of any pathology and to facilitate reconstruction, it is important that the extent of canalplasty performed allows a complete view of the entire annulus without moving the microscope.

6.1.2 Posterior Epitympanotomy

1. The attic is opened from behind, keeping the superior canal wall intact. Drilling of this area should be conducted from medial to lateral (► Fig. 6.5, ► Fig. 6.6). Inattentive drilling with a burr inserted into the attic easily insult the incus located behind the bone (► Fig. 6.7). It is important to recognize that the short process of the incus is closer to the surgeon than its body, and the short process is very close to the bone covering it (► Fig. 6.8). The posterior atticotomy should have enough anterior extension to control the whole attic completely. The final bony overhang covering the incus may be removed with a curette (► Fig. 6.9). For early identification of the incus, it is very important to shift visual axis more posteriorly by rotating the bed away from the surgeon after opening the sinodural angle sufficiently.
2. The area is limited superiorly by the middle cranial fossa dura, inferiorly by the canal wall, and medially by the ossicular chain. The utmost care should be taken not to touch the ossicular chain with the burr when the chain remains intact. If there is a risk, the incudostapedial joint should be disarticulated first. In this case, reconstruction of the ossicular chain may be performed either at the end of the surgery or in the second-stage operation, depending on the pathology.
3. Care should be taken not to fenestrate the superior wall of the external auditory canal. If it occurs, reconstruction with cartilage and bone pâté is necessary. Care should be taken not to injure the middle fossa dura. The dura is very fragile especially in the elderly, and cerebrospinal fluid (CSF) leak may follow. In addition, exposure of the middle fossa dura may cause meningoencephalic herniation. To avoid excessive removal of the bone, never press the burr heads against superior (middle fossa plate) and inferior (superior meatal wall) bony walls in this area.
4. A retraction pocket with small epitympanic erosion may be dissected and pushed out to the external auditory canal from the attic cavity with a small cottonoid (► Fig. 6.10). In order to ventilate the epitympanum via the anterior epitympanum, the overhanging cog is removed either with a curette or with a burr after the malleus head is mobilized.
5. In case of attic cholesteatoma extending into the anterior epitympanum, the incus is removed and the head of the malleus is cut, and the cog is removed with either a burr or a curette to open the anterior epitympanum.
6. In cases with both retraction pocket and attic cholesteatoma, sufficient removal of the lateral attic wall that impedes complete access to the entire attic is important to avoid leaving epidermis in the middle ear. However, to reduce the possibility of cholesteatoma recurring, a very large atticotomy should be avoided.

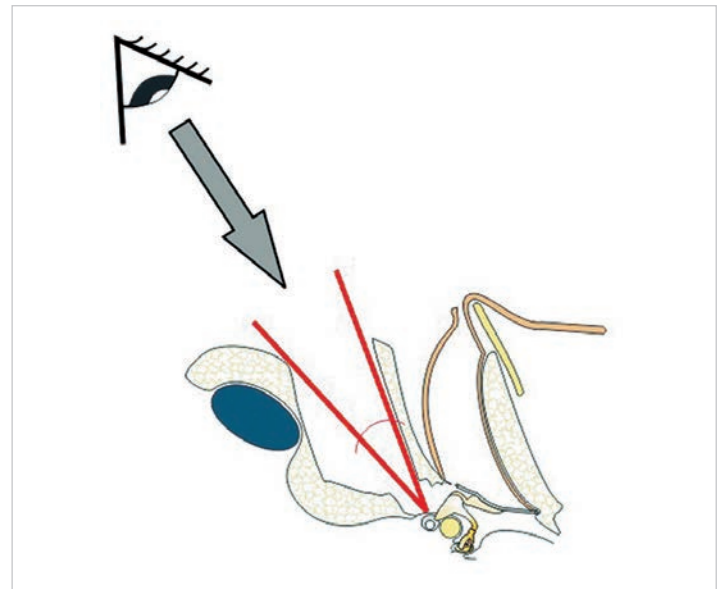


Fig. 6.3 Bad cavity.

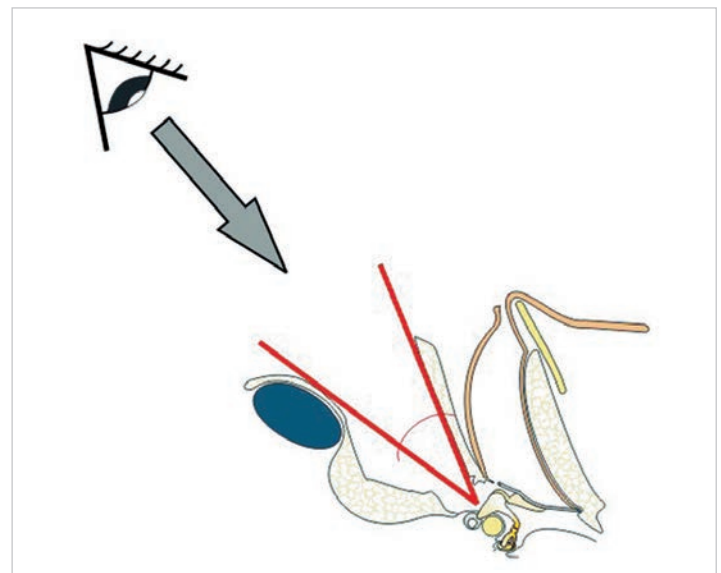


Fig. 6.4 Saucerized cavity.

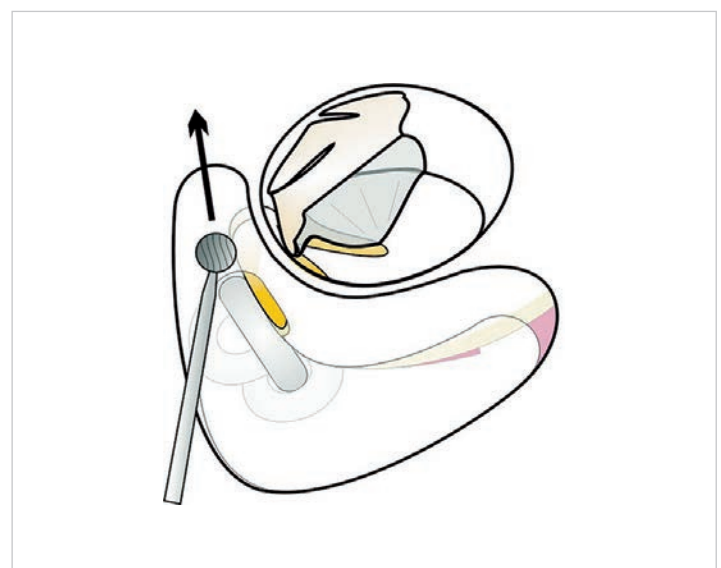


Fig. 6.5 Posterior epitympanotomy.

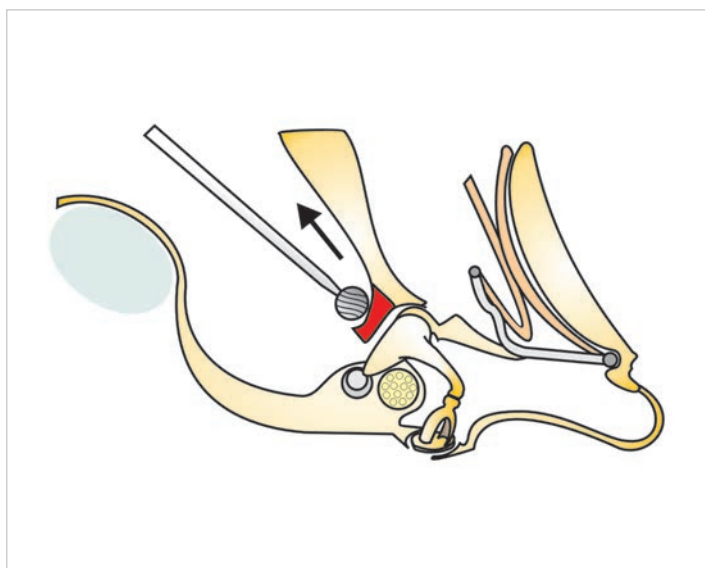


Fig. 6.6 Medial to lateral drilling in posterior epitympanotomy.

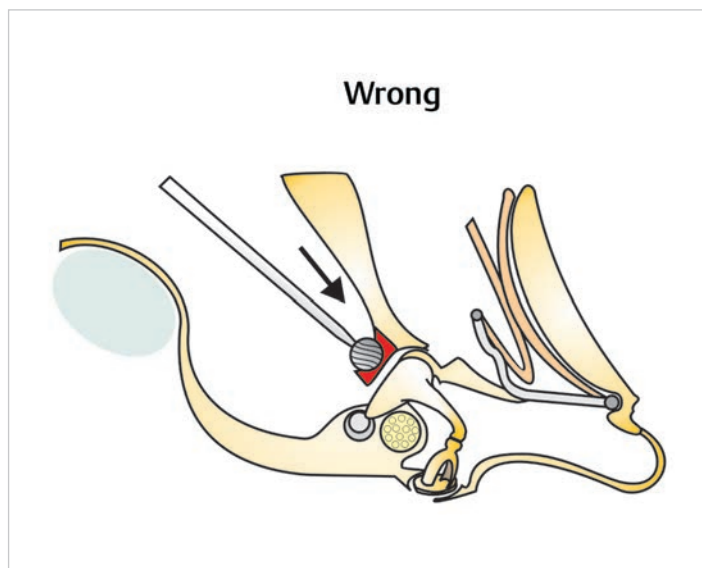


Fig. 6.7 Severe insult to the ossicular chain may happen with inattentive movement of the burr.

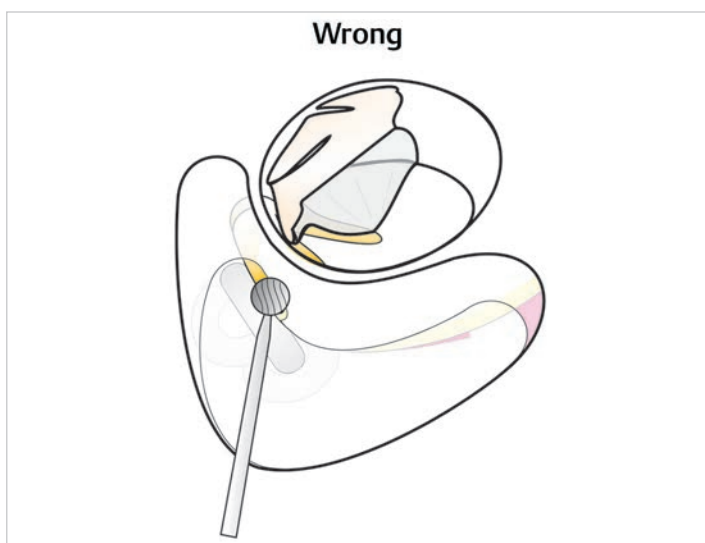


Fig. 6.8 Inattentive damage to the incus. The short process comes lateral, very close to the bone.

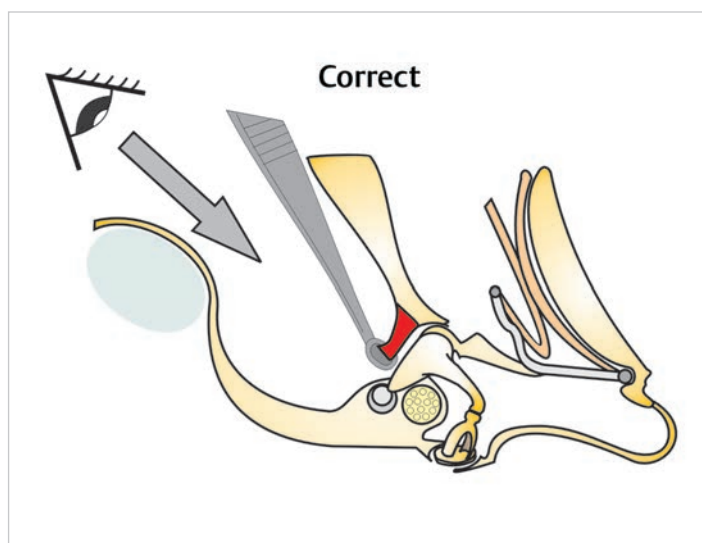


Fig. 6.9 Early identification of the incus to avoid inattentive damage.

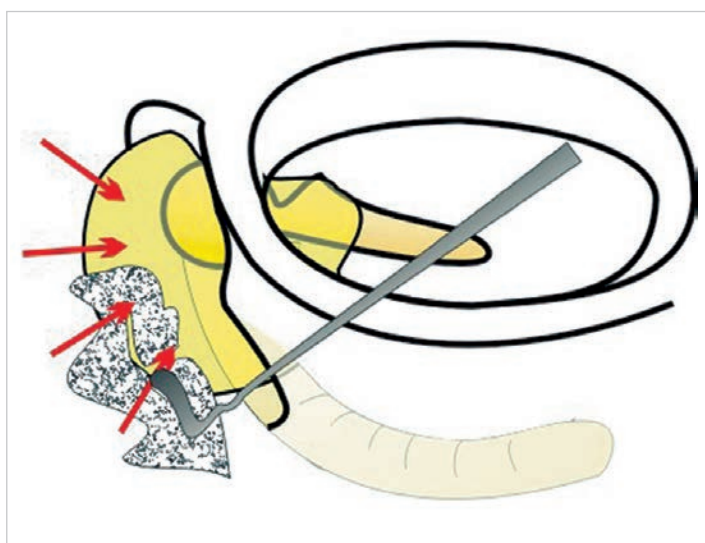


Fig. 6.10 Dissection of a retraction pocketed from the attic.

6.1.3 Posterior Tympanotomy

1. The posterior wall of the external auditory canal is thinned out. The final step is preferably carried out with a large diamond burr. *It is important not to make the posterior canal wall too thin.* Inadvertent opening or postoperative atrophy of the canal wall can lead to recurrent cholesteatoma, even after a considerable time, if tubal function is impaired.
2. To avoid facial nerve injury, positive identification of the facial nerve is valuable. The third portion of the facial nerve is identified using a large cutting burr, moved parallel to the course of the nerve, with continuous suction and ample irrigation. *The nerve is only skeletonized, never exposed.* Care should be taken not to open the lateral semicircular canal that is located just posterolateral to the facial nerve. The chorda tympani should also be identified.
3. Using a diamond burr or a curette, the facial recess between the facial nerve and the chorda tympani is opened (► Fig. 6.11). The chordal crest can be seen in this step (see ► Fig. 1.13). If the ossicular chain remains intact, a small buttress of bone may be left intact posterior to the short process of the incus to protect the chain from the burr.
4. The size of posterior tympanotomy depends on how far the pathology has extended to the facial recess and the sinus

tympani. Opening between the facial nerve and the chorda tympani is usually sufficient to control the area of the incudostapedial joint and the oval window (► Fig. 6.12). If the round window and/or hypotympanum should be managed, the posterior tympanotomy may be extended

inferiorly after transecting the chorda tympani (► Fig. 6.13, ► Fig. 6.14).

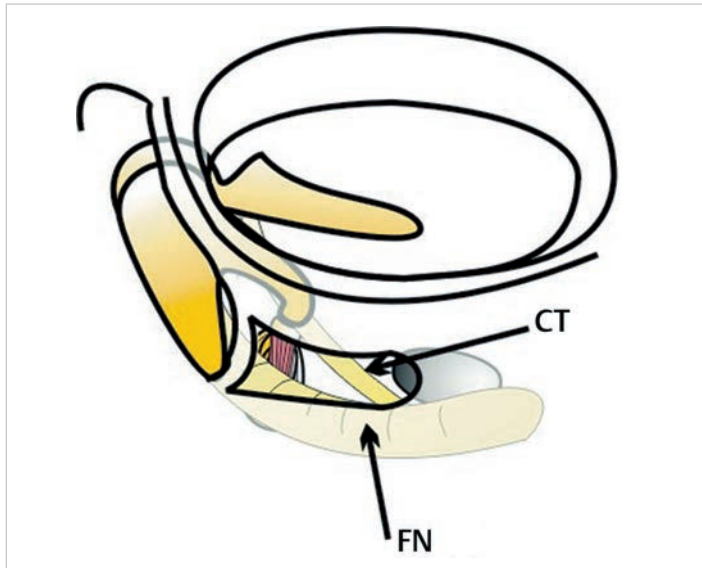


Fig. 6.11 Facial recess. CT, chorda tympani; FN, facial nerve.

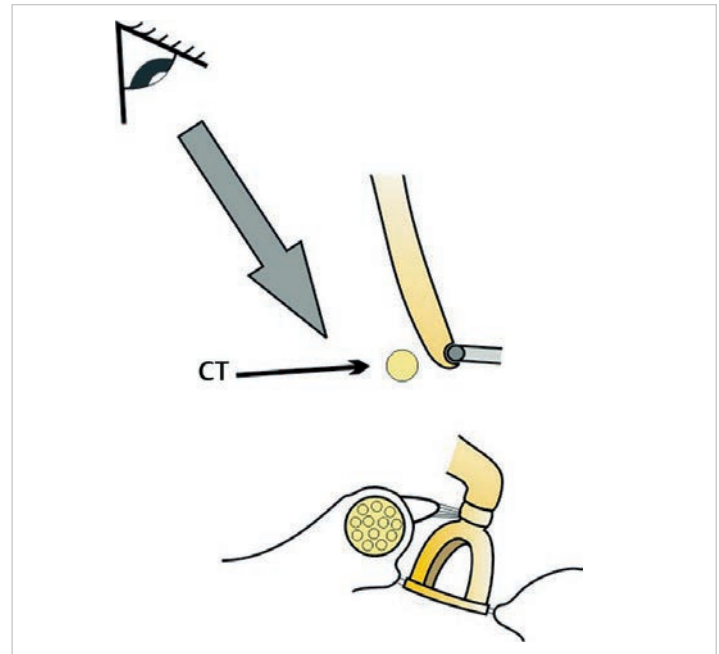


Fig. 6.12 The incudostapedial joint and oval window can be controlled through a posterior tympanotomy. CT, chorda tympani.

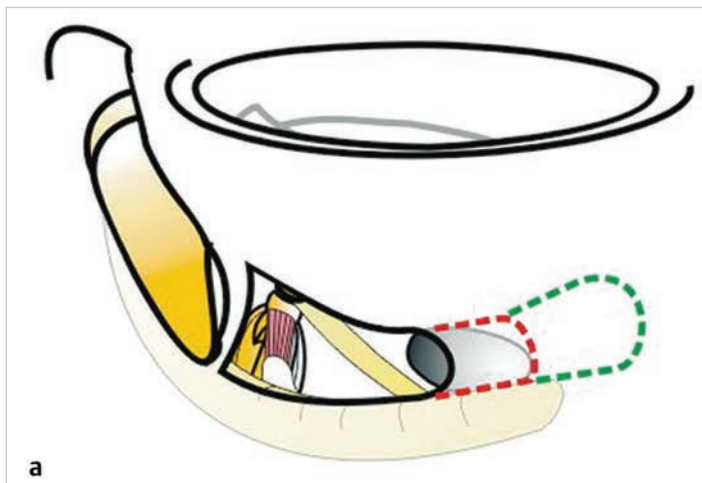


Fig. 6.13 (a) Extension of the posterior tympanotomy to the area of the round window (red dotted line), and to the area of hypotympanum (green dotted line). (b) Extended posterior tympanotomy to control cholesteatoma in hypotympanum.

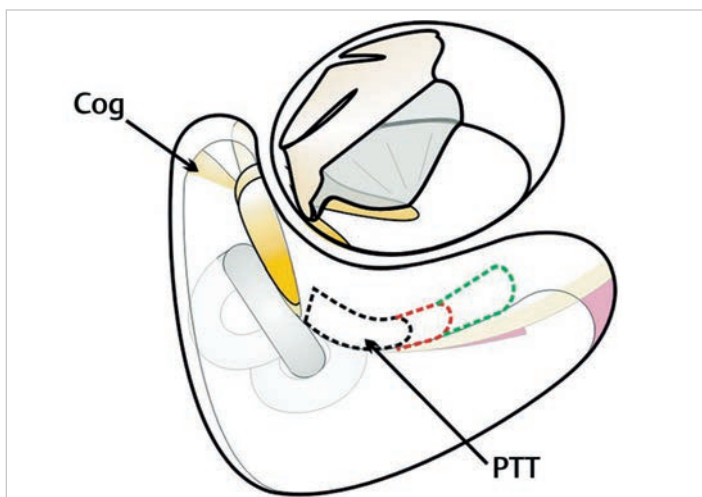


Fig. 6.14 Combined view through a posterior tympanotomy (PTT) and the external auditory canal.

6.1.4 Middle Ear Management

General Considerations

1. The tympanomeatal flap is elevated with the posterior annulus. The middle ear is explored through both posterior tympanotomy and the external auditory canal.
2. It is better to finish management of the middle ear as soon as possible. In this way, complete hemostasis is achieved before reconstruction. On the other hand, management of the oval and round window areas is conducted after completing bone work. The surgeon should find right moment to complete middle ear management in each surgical operation.
3. The pathology is dissected from the middle ear, taking care not to damage the fragile structures.
4. Dissection of pathology from fragile structures in the tympanic cavity is carried out in a combined approach, with one instrument introduced from the external auditory canal and the other from the posterior cavity (► Fig. 6.15). In this way, even though two required instruments are introduced simultaneously into the restricted area, the narrow view of delicate structures, through either tympanotomies or the meatus, is not obstructed by the instruments.

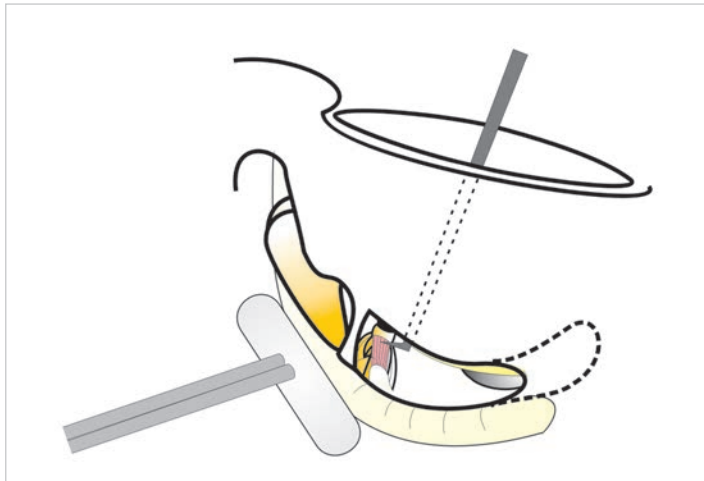


Fig. 6.15 Combined approach. Instruments are introduced simultaneously through the external auditory canal and the posterior tympanotomy.

5. The tympanic membrane and the ossicles may be removed depending on the lesion. The tympanic membrane is repaired using the temporalis fascia if some defect or a perforation exists.

Cholesteatoma Removal

1. Dissection of cholesteatoma starts with removal of its debris, leaving the intact matrix in place (► Fig. 6.16). In this way, the structures under the cholesteatoma are seen either directly or through the matrix before completely elevating the matrix, and the dissection can be carried out more safely.
2. To leave matrix as intact as possible, a blunt dissection of the matrix with the help of cottonoids and a suction tip is carried out (► Fig. 6.17).

Antrum and Attic

1. Absence of labyrinthine fistula should be looked for carefully, especially in the area of the lateral semicircular canal (► Fig. 6.18). A fistula can be seen through thin matrix as a bluish spot or line. If fistula is identified, or the highly suspicious area is covered with thick tissue, management of that area should be left until the final moment of the surgery (see Chapter 10).

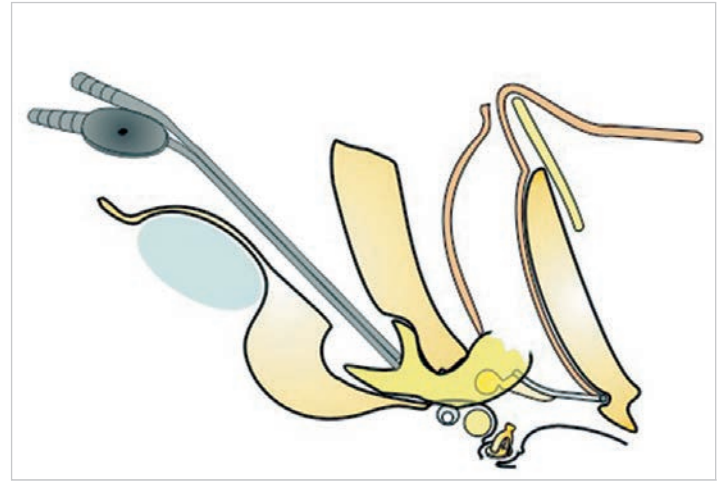


Fig. 6.16 First step in cholesteatoma dissection. Remove debris leaving the matrix intact.

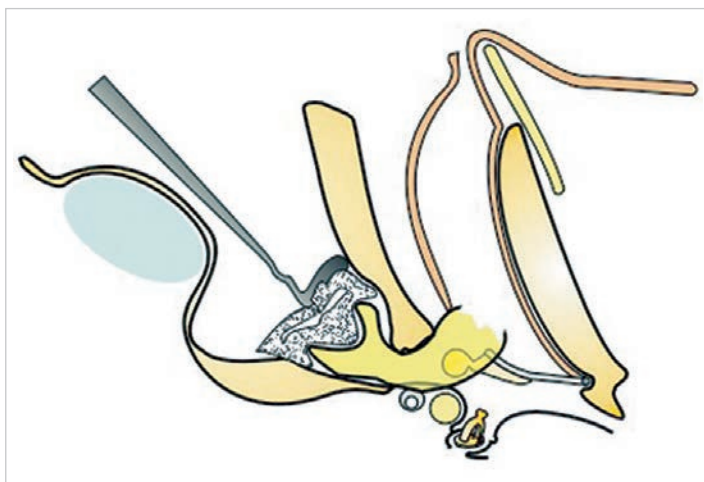


Fig. 6.17 Blunt dissection of cholesteatoma matrix with a piece of cottonoid.

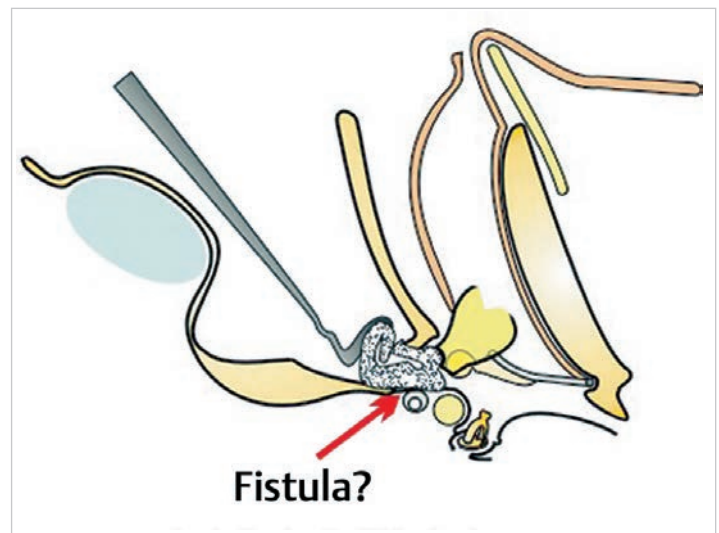


Fig. 6.18 When the dissection reaches to the area of the labyrinth, presence of labyrinthine fistula should always be suspected.

2. In the antrum and the attic, the dissection is carried out with help of cottonoid, a suction tip, and the microdissectors (# 1 or #2 in ►Fig. 3.29). The matrix is gently elevated and pushed toward the attic, and the tympanic cavity.

Oval Window

1. At first-stage surgery, excessive attempts at removing cholesteatoma from this area is proscribed. If there is any risk to open the vestibule, the matrix can be left over the stapes. In such cases, second-stage surgery should be planned to take place within 6 months.
2. Dissection of cholesteatoma from the area of the windows is started after all bone work has been completed. All maneuvers on the stapes superstructure should be carried out with extreme care. Dissection is conducted along long axis of the footplate, never perpendicular to it.
3. If the matrix covers the stapedius tendon, the tendon should be cut. If the matrix adheres underneath the arch of the superstructure, the superstructure is also removed with long and straight spring scissors (see ►Fig 2.9) taking care not to fracture the footplate. Do not use crurotomy scissors. It could damage the footplate.
4. If the superstructure is absent, the matrix may be dissected through the meatus. Sufficient visualization of this area is the key to safe and complete removal. For this reason, position of the patient is very important. The bed should be tilted toward the surgeon and in a head-down position. Removal of a small

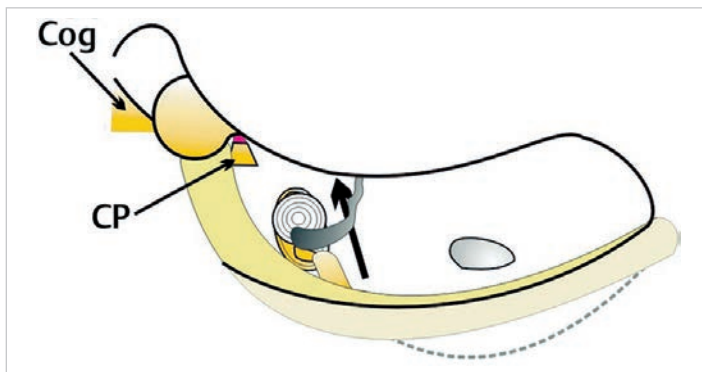


Fig. 6.19 Cholesteatoma matrix in the area of the oval window is removed in a posterior to anterior direction. CP, cochleariform process.

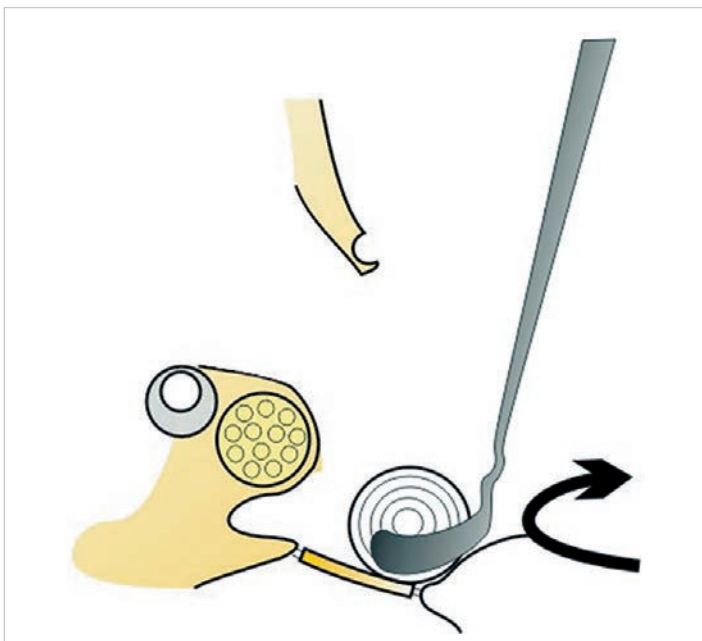


Fig. 6.20 A closer view of ►Fig. 6.19.

part of the posterior canal wall might be required. Sometimes, the pyramidal eminence needs to be removed with either a small curette or a small diamond burr. The matrix is removed from the footplate from a posterior to anterior direction (►Fig. 6.19, ►Fig. 6.20).

Round Window

1. If the matrix covers the round window niche, its removal starts from the promontory or the hypotympanum with an instrument introduced through the meatus. In some case, removal of a bony overhang in the superior edge covering the niche is required.

Hypotympanum

1. Rarely, the hypotympanic cells are infiltrated by cholesteatoma matrix (►Fig. 6.21). In such cases, area between the jugular bulb and the carotid artery is carefully drilled. It is preferable to start drilling with a largest possible cutting burr, since cutting burrs hardly bury cholesteatoma matrix

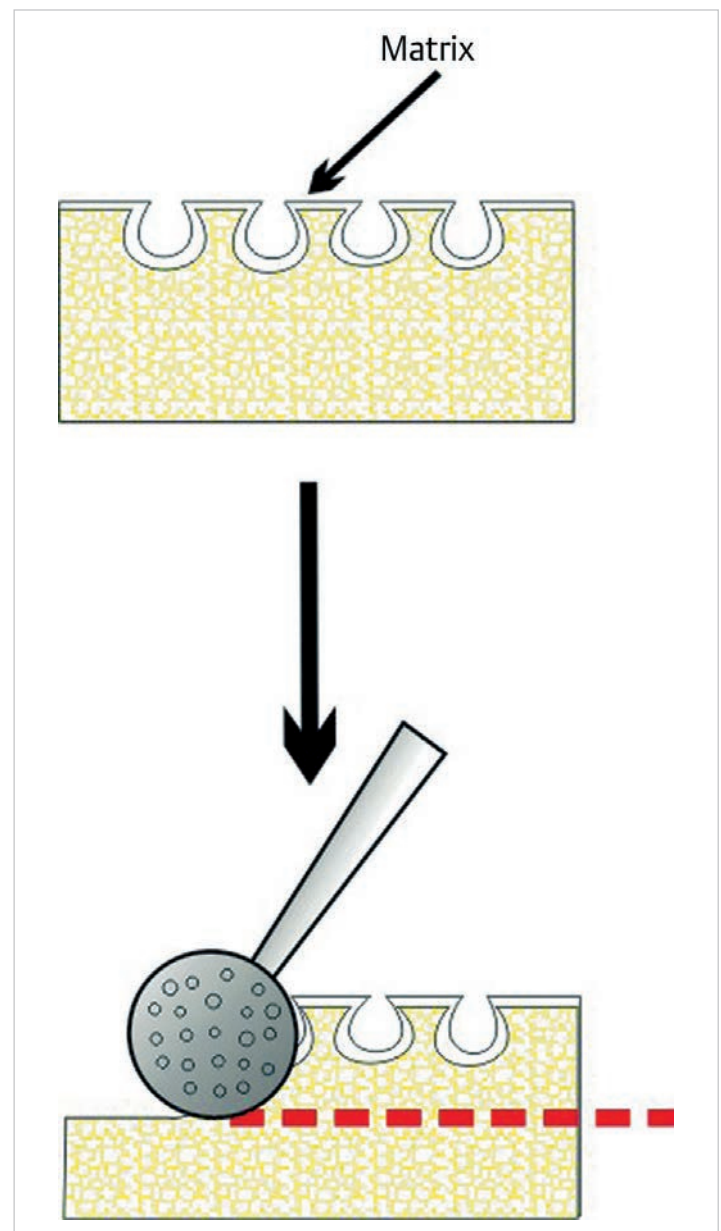


Fig. 6.21 When hypotympanic air cells are infiltrated, they should be drilled out carefully until healthy bone is reached.

in cells (see Chapter 4). Diamond burrs are preferred when the drilling approaches the great vessels. Great care should be taken not to damage the jugular bulb, since the structure is extremely fragile.

2. If there is any doubt of residual matrix, the surgery should be either staged or transferred to CWD technique with exteriorization of the hypotympanic area.

Tympanic Sinus and Posterior Mesotympanum

1. Dissection of cholesteatoma matrix from the tympanic sinus and posterior mesotympanum is carried out as a combined approach, working through the mastoid and the canal at the same time, with a suction tube held in one hand and a tympanic sinus hook in the other (►Fig. 6.22). The maximum view of the bottom of the tympanic sinus is obtained through the canal, with the patient's bed deeply tilted toward the surgeon. Nevertheless, the surgeon is usually forced to dissect in blind fashion, to some extent, medial to the facial nerve. A small cottonoid is placed between the bone and the matrix, and the matrix is detached from the bone

taking care to preserve its continuity as much as possible (►Fig. 6.23a, b).

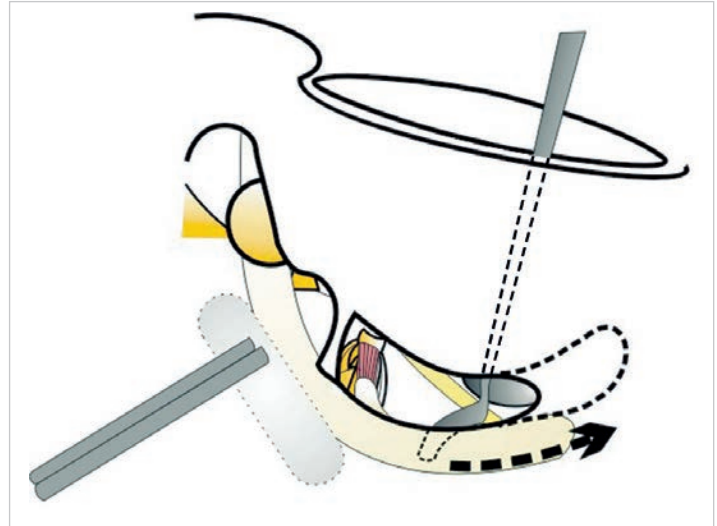


Fig. 6.22 Combined approach for dissection in the tympanic sinus area.

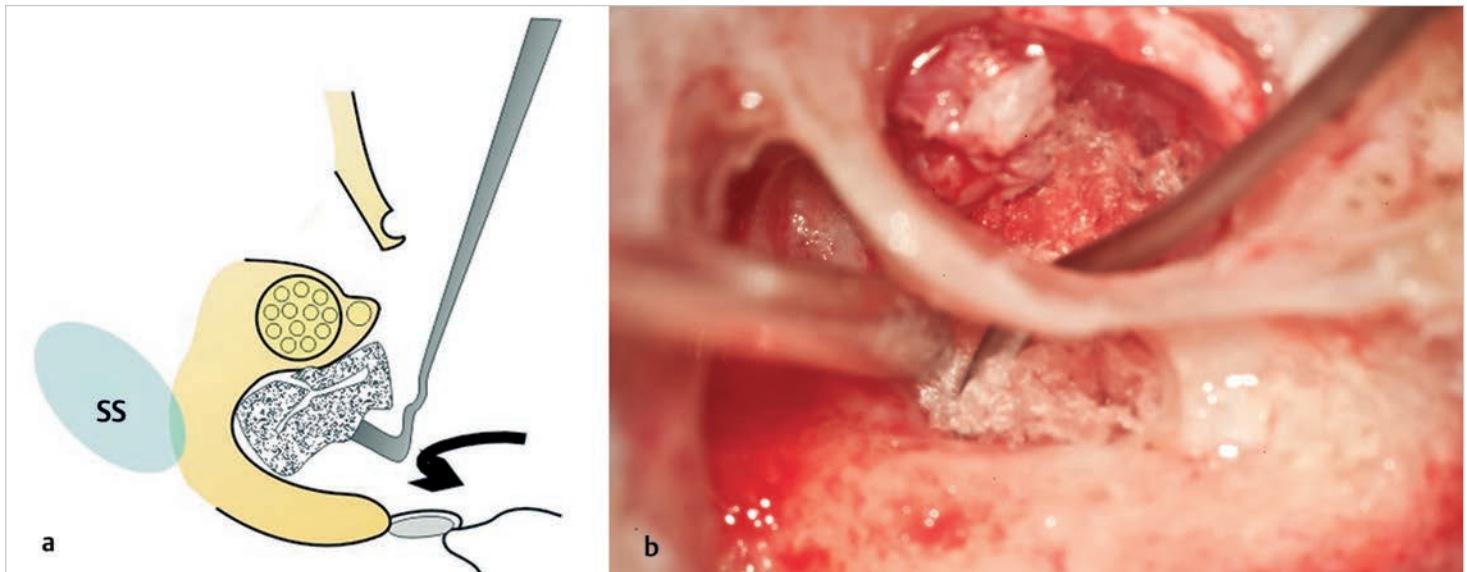


Fig. 6.23 (a) Dissection of cholesteatoma from tympanic sinus using a cottonoid and a tympanic sinus hook. SS, sigmoid sinus. (b) Cholesteatoma dissection from the tympanic sinus with the help of cottonoid. A cholesteatoma is detached from the tympanic sinus using a combined approach. A tympanic sinus hook is passed through the external auditory canal, and a suction tube through the attic.

6.1.5 Reconstruction

1. Every defect of the posterosuperior bony canal wall should be immediately repaired. Erosion of the superior bony annulus may be repaired with a large cartilage inserted from the posterior cavity. The cartilage may be reinforced with bone pâté. If the manubrium is present, small cut may be made in the cartilage (► Fig. 6.24).
2. The cartilage is then covered from its meatal side with bone pâté mixed with blood. Reconstruction only with either autologous or homologous cartilage usually results in atrophy of the posterior wall, which may eventually cause recurrence. We always use bone pâté with cartilage for reconstruction of the canal wall. The bone pâté is further covered with a thin piece of cartilage from the canal side (Sandwich technique; ► Fig. 6.25).
3. In cases with a retraction pocket in the posterosuperior quadrant, the posterior aspect of the tympanic membrane may be reinforced with a thin cartilage.
4. In cases of cholesteatoma, atelectasis and extensive mucosal defects in the medial wall, a medium-to-thick Silastic sheeting, sufficiently large to cover the medial wall of the middle ear including the tubal orifice, the epitympanum, the opened facial recess, and the mastoid, are inserted from the mastoid (► Fig. 6.26). The Silastic sheeting helps to avoid adhesions between the graft and denuded tympanic wall and to promote good mucosal regeneration.
5. The eustachian tube, and subsequently, the tympanic cavity are packed with small pieces of Gelfoam placed over the Silastic sheeting. Any defect in the tympanic membrane should be reconstructed with the temporalis fascia.
6. A tympanostomy tube may be inserted in the anterosuperior quadrant in cases of tubal insufficiency.

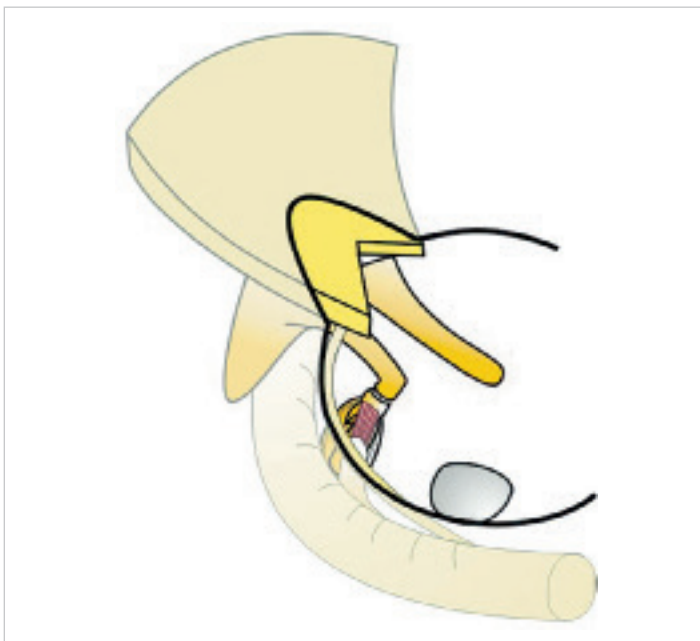


Fig. 6.24 When the manubrium is present, a small notch is made in the cartilage used to reconstruct the canal wall.



Fig. 6.26 Silastic sheeting used to cover the medial wall. Note the shape and size.

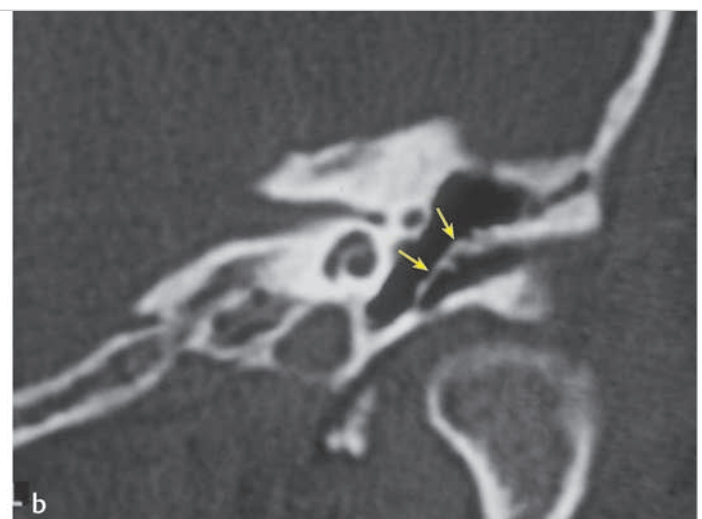
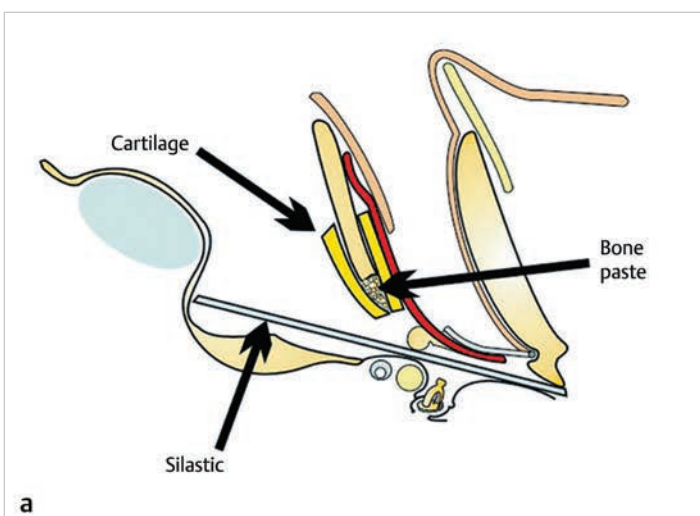


Fig. 6.25 (a) Sandwich technique for reconstructing canal wall. (b) Postoperative CT after Sandwich technique showing pneumatized middle ear and the reconstructed posterior wall with ossification (arrows).

6.1.6 Closure

1. The external auditory canal is packed with small pieces of Gelfoam, first anteriorly, then superiorly and inferiorly. The posterior wall is left unpacked at this stage. The self-retaining retractor is removed and folded gauze is placed on the retroauricular wound. The auricle is placed back in its position. Using a nasal speculum, the meatus of the external auditory canal is held and widened. After identifying its edge by pulling it up with forceps, the posterior meatal skin is correctly unfolded over the canal wall. The posterior wall and then entire canal are packed with Gelfoam.
2. In closed tympanoplasty, since there is an opening of the mastoid cavity posterior to the canal, the laterally based posterior meatal skin flap may slip into the mastoid cavity, especially when canalplasty is performed. Make sure that the posterior meatal skin is long enough to stay within the canal (► Fig. 6.27). Short meatal skin may cause iatrogenic cholesteatoma (► Fig. 6.28, ► Fig. 6.29). If the skin flap is short, it should be sufficiently undermined to lengthen it, and a subcutaneous tissue flap is harvested behind the meatal skin (► Fig. 6.30). The subcutaneous flap is interposed between the posterior bony canal wall and the skin flap to support the skin flap from behind (► Fig. 6.31). As alternatives to this technique, the short posterior meatal skin can

be sutured to the bony canal wall after creating small holes in the wall, or a thin piece of cartilage may be placed over the posterior canal wall.

3. The musculoperiosteal layer is held in position with a couple of sutures, and the skin is closed in two layers. *We never use transmastoid drainage, since it is unnecessary and may become a source of infection.*

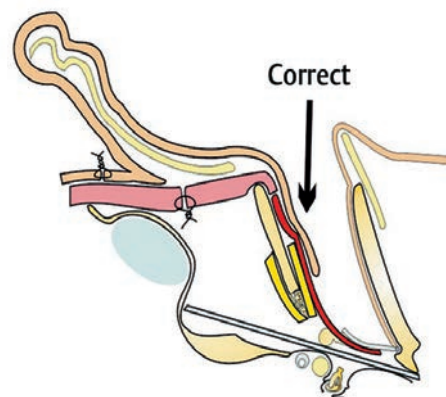


Fig. 6.27 The posterior meatal skin should be sufficiently long to stay in the canal.

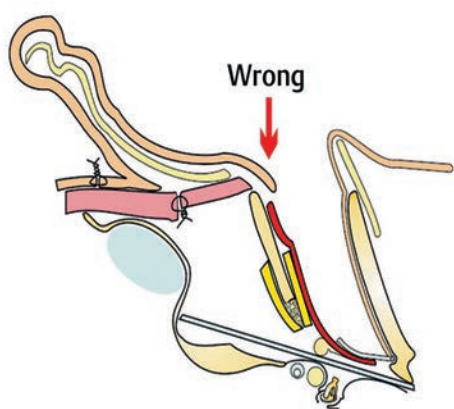


Fig. 6.28 A short posterior meatal skin flap may fall into the mastoid.

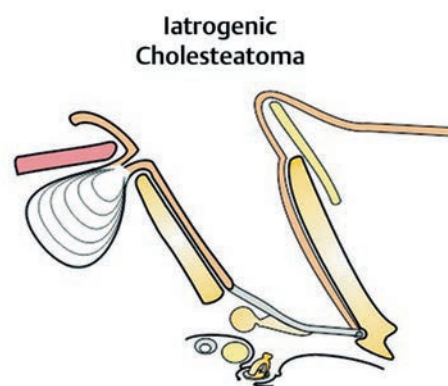


Fig. 6.29 Iatrogenic cholesteatoma resulting from a short flap sucked into the mastoid cavity.

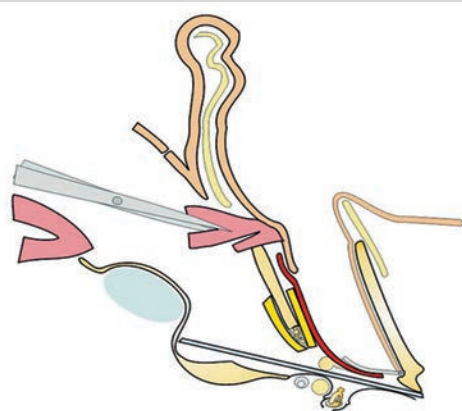


Fig. 6.30 Creating a subcutaneous flap to support the posterior meatal skin.

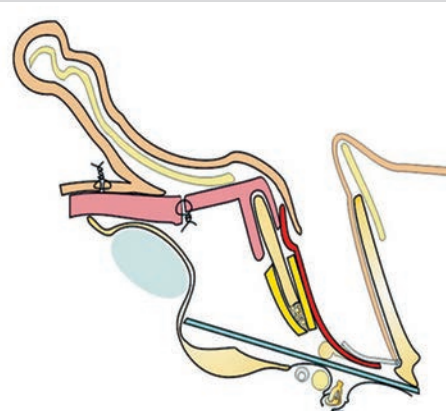


Fig. 6.31 The subcutaneous tissue flap in position.

Case 6.1 (Right Ear)

See ▶Fig. 6.32, ▶Fig. 6.33, ▶Fig. 6.34, ▶Fig. 6.35, ▶Fig. 6.36, ▶Fig. 6.37, ▶Fig. 6.38, ▶Fig. 6.39, ▶Fig. 6.40, ▶Fig. 6.41, ▶Fig. 6.42, ▶Fig. 6.43, ▶Fig. 6.44, ▶Fig. 6.45, ▶Fig. 6.46, ▶Fig. 6.47, ▶Fig. 6.48, ▶Fig. 6.49, ▶Fig. 6.50, ▶Fig. 6.51, ▶Fig. 6.52.

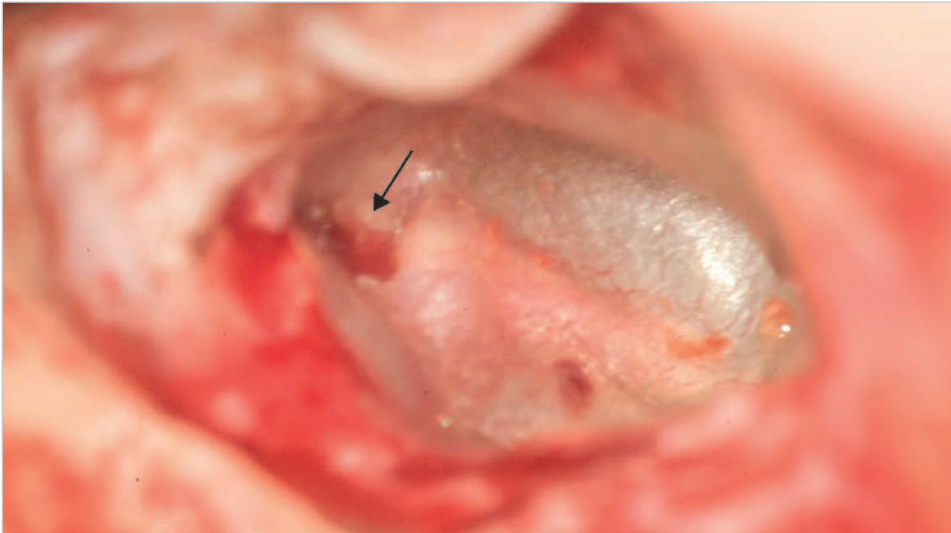


Fig. 6.32 The patient suffered from left hearing loss with tinnitus for years. Radiological examination revealed a vestibular schwannoma in the left ear. An asymptomatic noninflamed cholesteatoma was found in the right ear by chance. Progressive course of the cholesteatoma with active inflammation forced us to perform tympanoplasty. Since the mastoid is highly pneumatized, canal wall up procedure without insulting the ossicular chain is planned. A small erosion in the pars flaccida is seen (arrow).

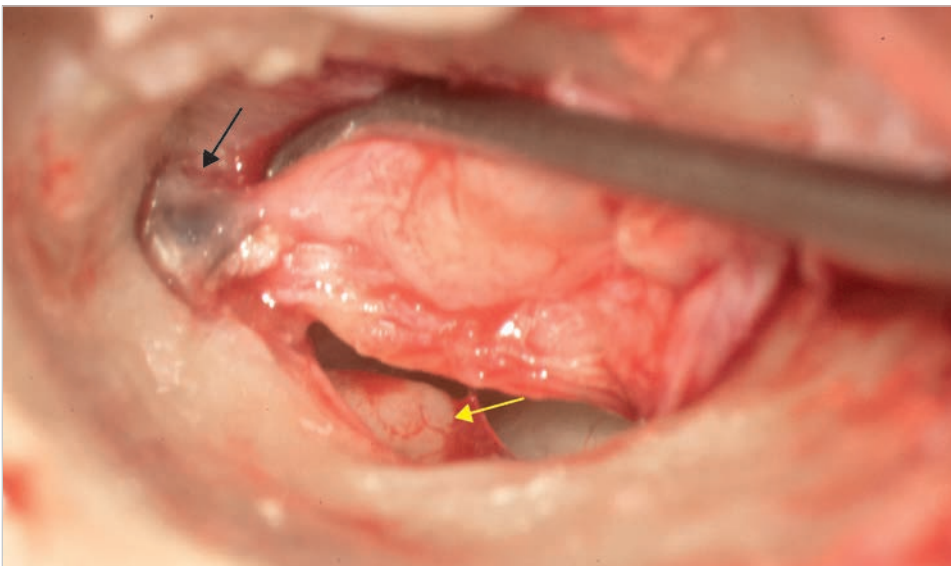


Fig. 6.33 The tympanic cavity is opened, and the incudostapedial joint (yellow arrow) is visualized. No cholesteatoma is seen in the mesotympanum. A small orifice of pars flaccida-type cholesteatoma is shown (black arrow).

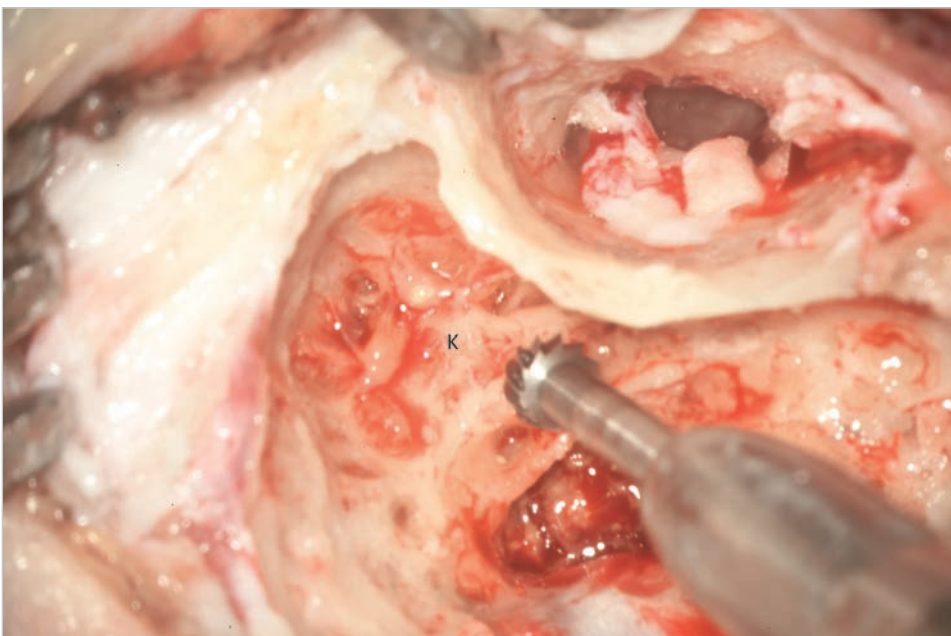


Fig. 6.34 The highly pneumatized mastoid is opened, and the Körner's septum separating the antrum from the lateral part of the mastoid is visualized. K, Körner's septum.

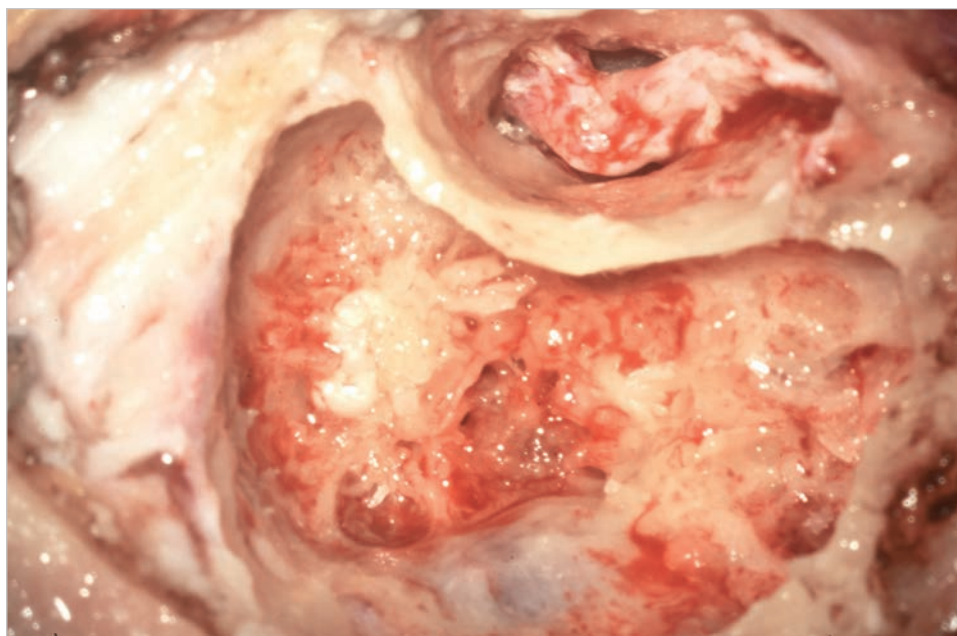


Fig. 6.35 Removal of the Körner's septum visualized the distal end of cholesteatoma filling the antrum.

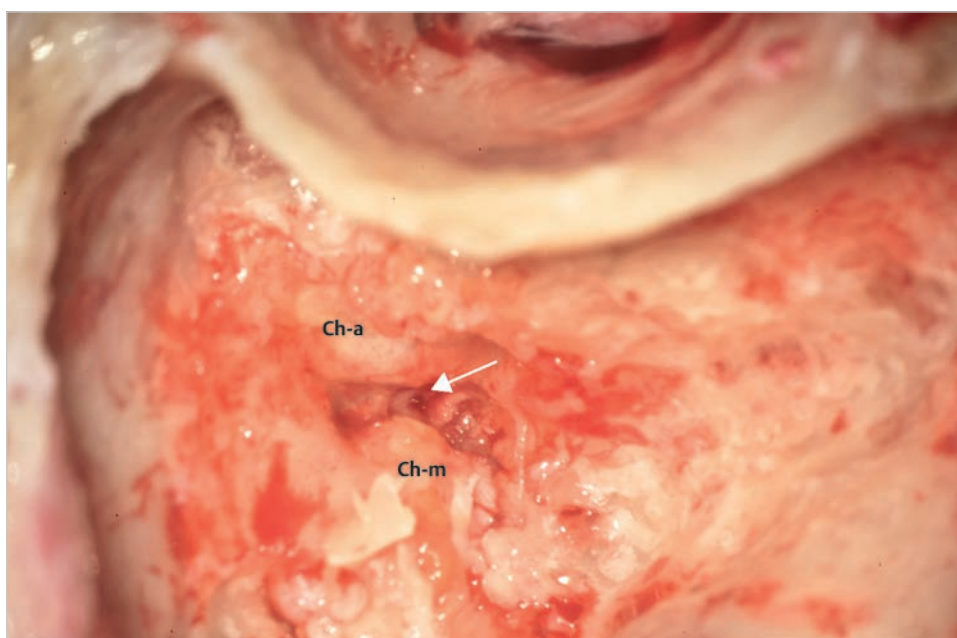


Fig. 6.36 Dissection of the cholesteatoma in the mastoid visualized a clear cleavage in the cholesteatoma (*arrow*). With that cleavage, the cholesteatoma in the mastoid (Ch-m) is completely separated from the one in the attic (Ch-a).

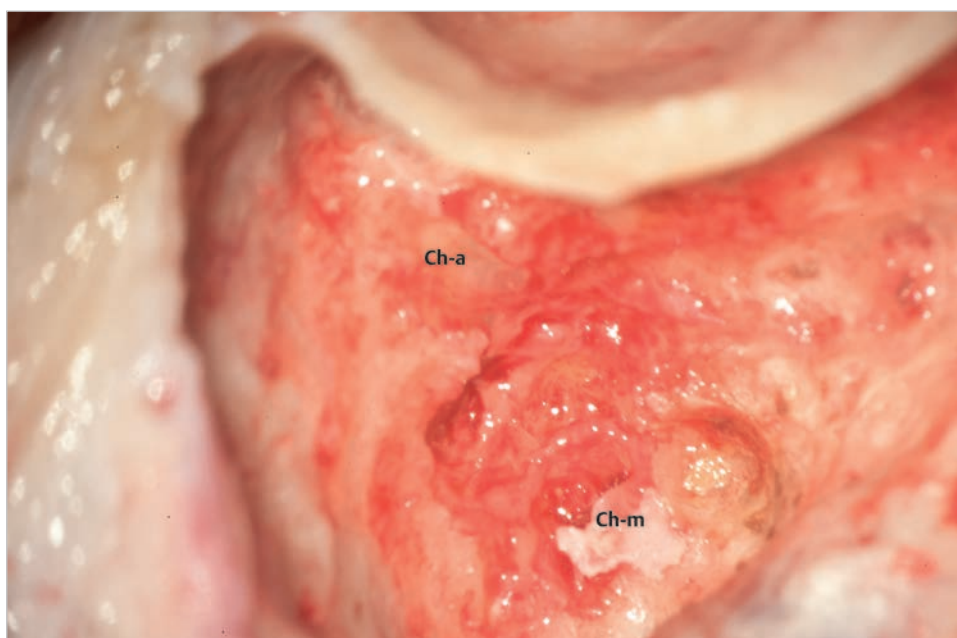


Fig. 6.37 Note the complete separation of two cholesteatomas. Even though such case is very rare, the situation may cause residual cholesteatoma if the pathology is followed and removed from the attic. Ch-a, cholesteatoma in attic; Ch-m, cholesteatoma in mastoid.

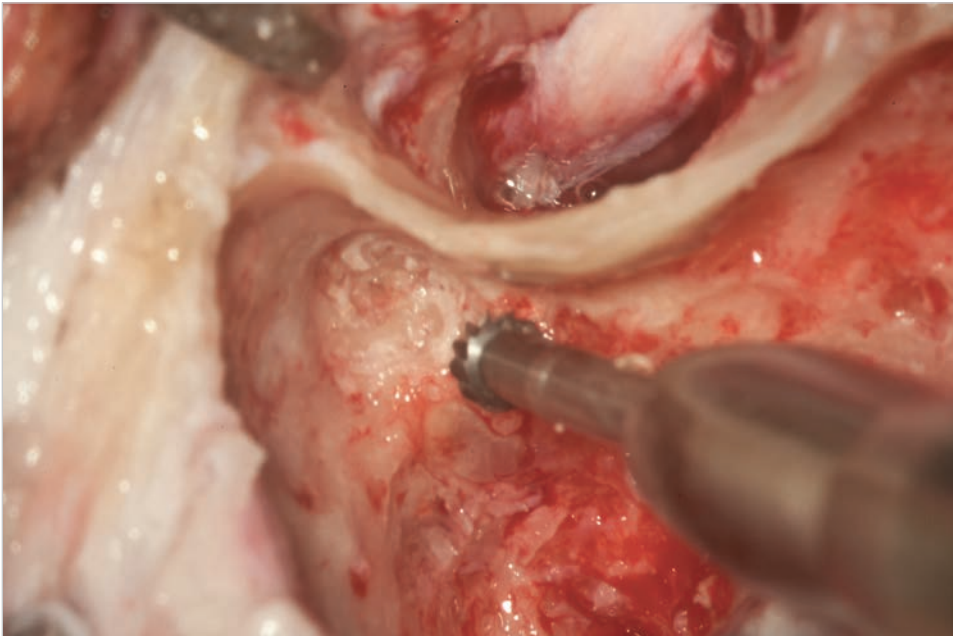


Fig. 6.38 The cholesteatoma is removed from the mastoid. The drilling is advanced anteriorly to manage the cholesteatoma filling the attic.

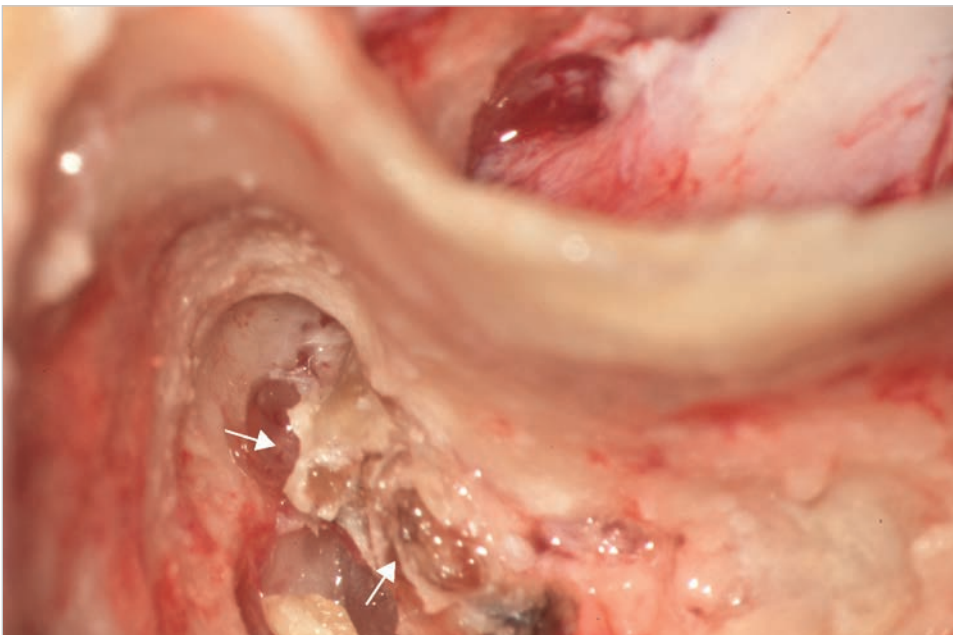


Fig. 6.39 The attic is opened to reduce cholesteatoma occupying it. Care should be taken not to touch the intact ossicular chain. The superior aspect of the chain covered by the cholesteatoma matrix is started to be seen (arrows).

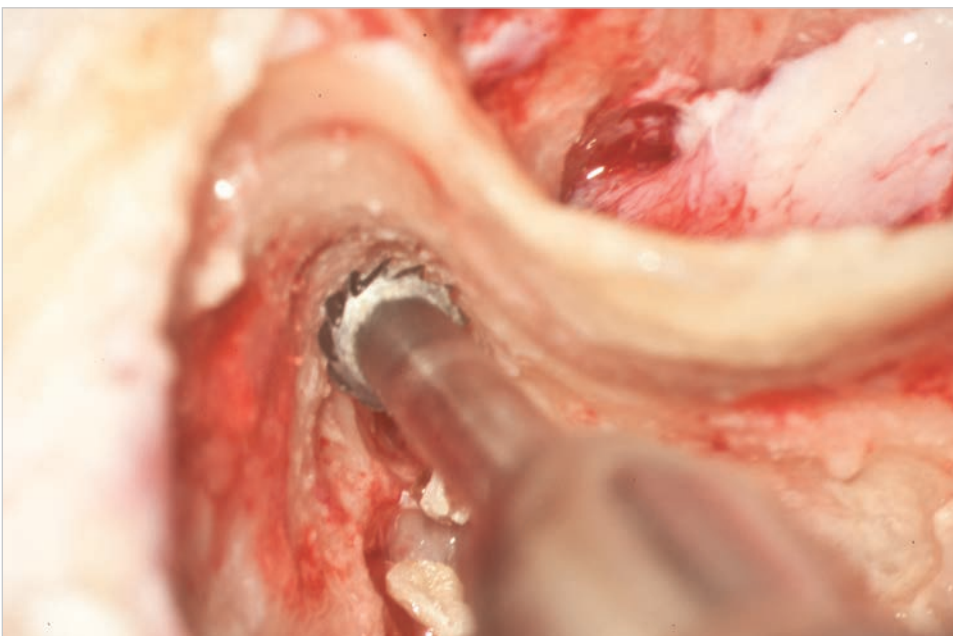


Fig. 6.40 Approach to the attic is enlarged with a small cutting burr so as to dissect the matrix from the ossicular chain. To avoid touching the ossicular chain with burrs, the drill should be moved either from medial to lateral, or parallel to the chain in this location. The bony overhang close to the ossicular chain is removed with a curette.

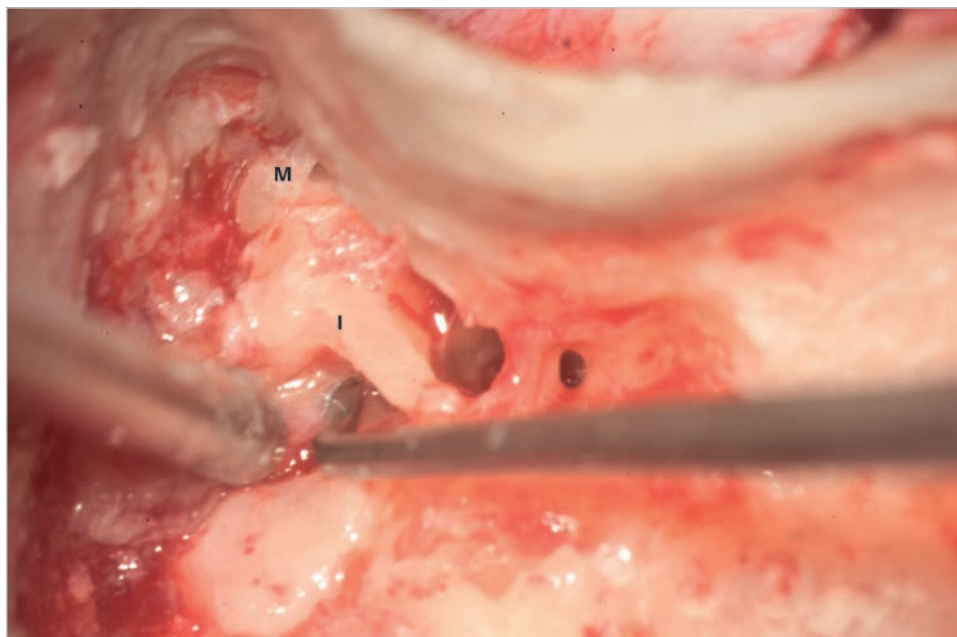


Fig. 6.41 A part of cholesteatoma located medially to the ossicular chain is started to be dissected with meticulous care not to disrupt the matrix covering its medial face. I, incus; M, malleus.

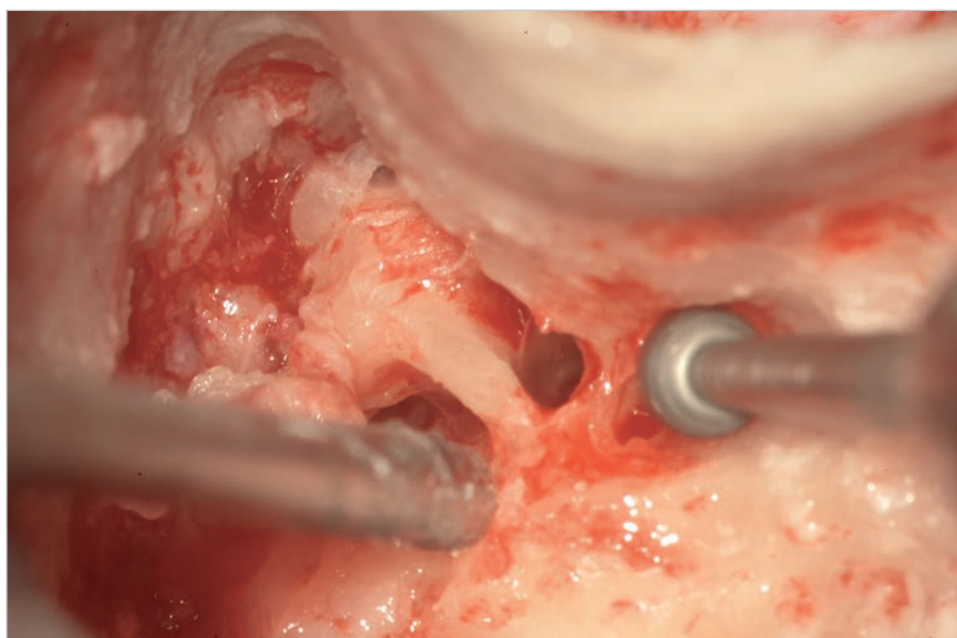


Fig. 6.42 To establish better access to the ossicular chain and ensure postoperative ventilation of the mastoid, a posterior tympanotomy is carried out.

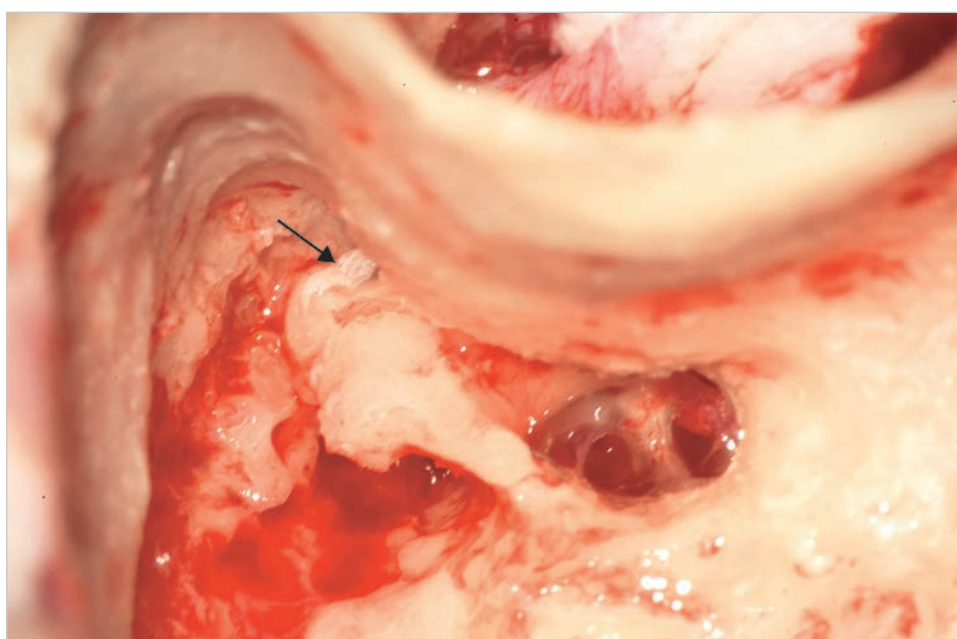


Fig. 6.43 Dissection of the cholesteatoma located medially to the ossicular chain is accomplished. Limited anterior extension of cholesteatoma enabled preservation of the ossicular chain. Cholesteatoma matrix still covers the lateral face of the ossicular chain (arrow).

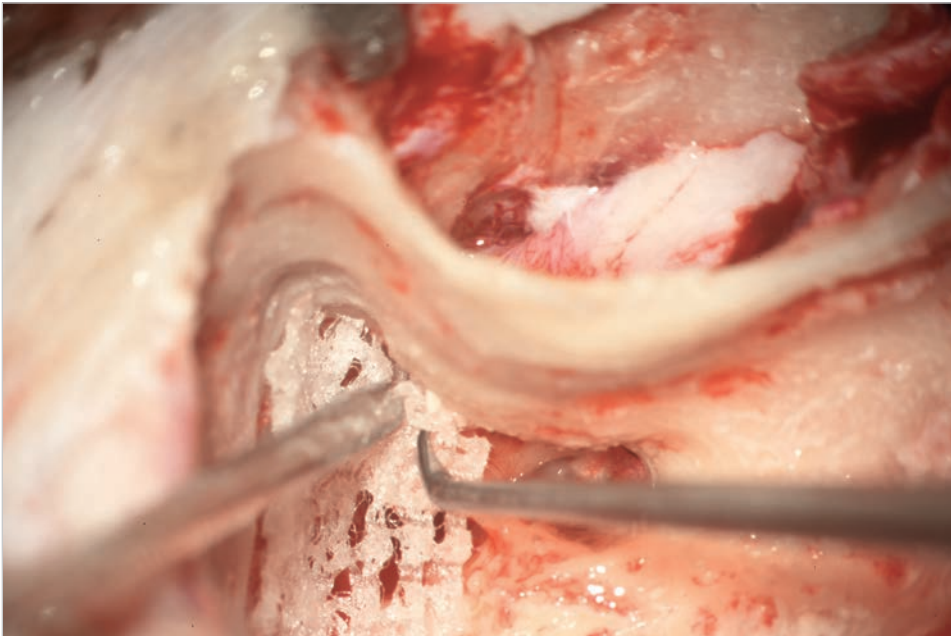


Fig. 6.44 The ossicular chain is scrubbed with cottonoid to ensure complete removal of the matrix.

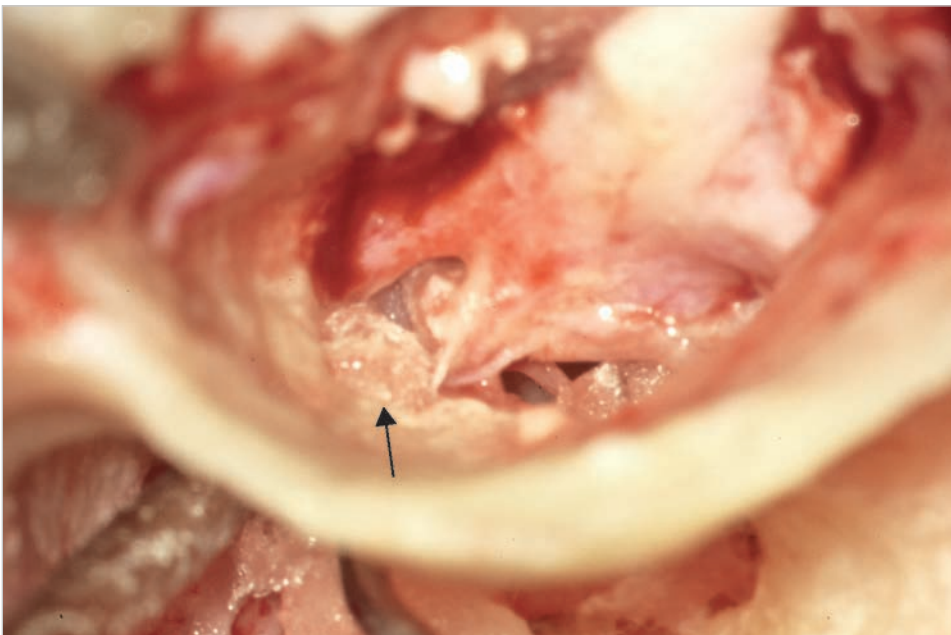


Fig. 6.45 With the help of cottonoid (*arrow*), the final piece of cholesteatoma matrix is pushed out toward the external auditory canal.

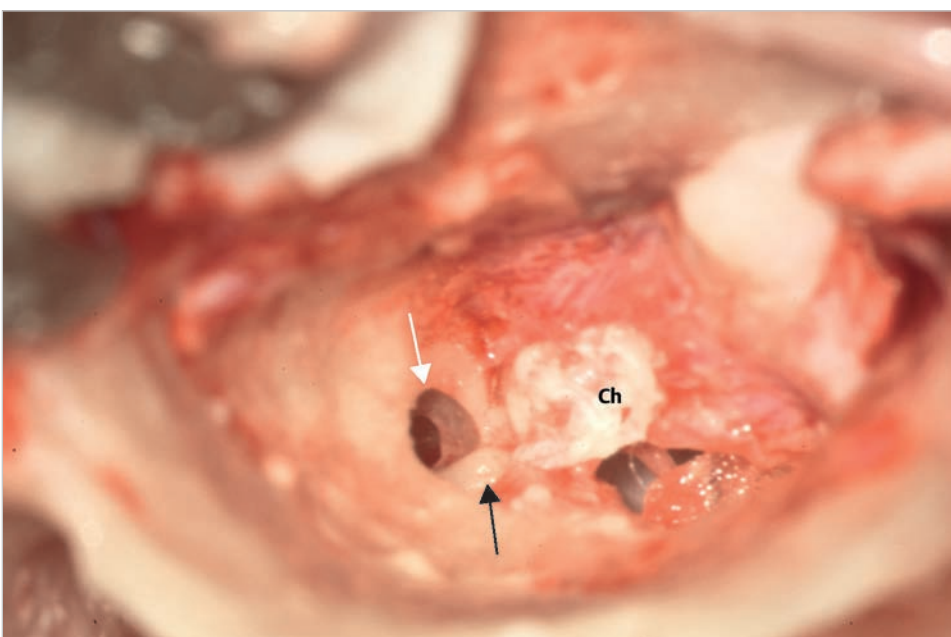


Fig. 6.46 A very small erosion in the pars flaccida served as an entrance of the cholesteatoma is seen (*white arrow*). The lateral process of the malleus (*black arrow*) is located just inferiorly to the erosion. The matrix pushed out from the orifice is seen. Eradication of cholesteatoma from the only hearing ear is accomplished without dissociating the ossicular chain. Ch, cholesteatoma.

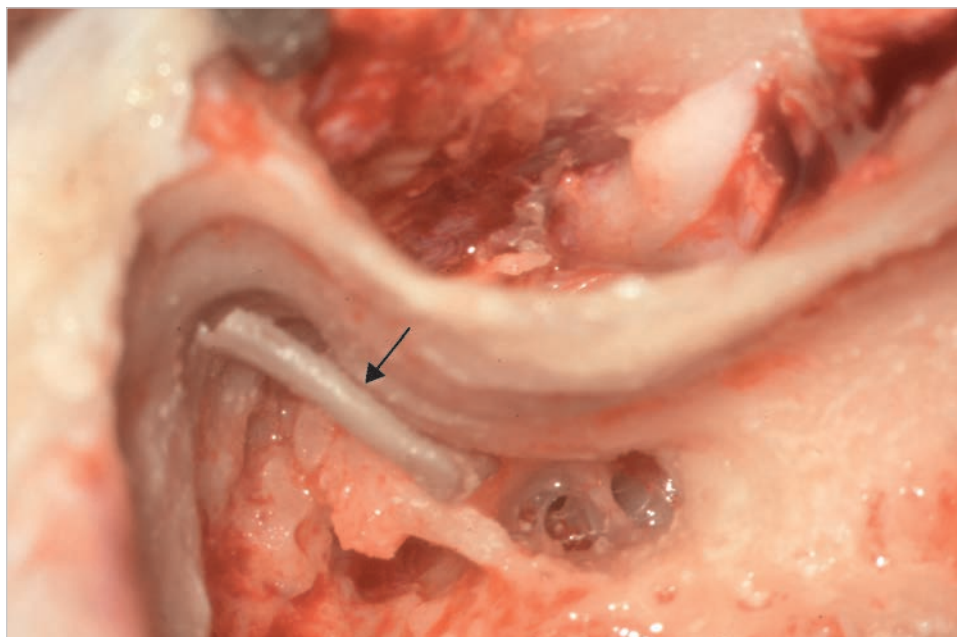


Fig. 6.47 A thin cartilage (*arrow*) is used to reconstruct the small bone erosion in the attic.



Fig. 6.48 The cartilage is supported with a large piece of Gelfoam.

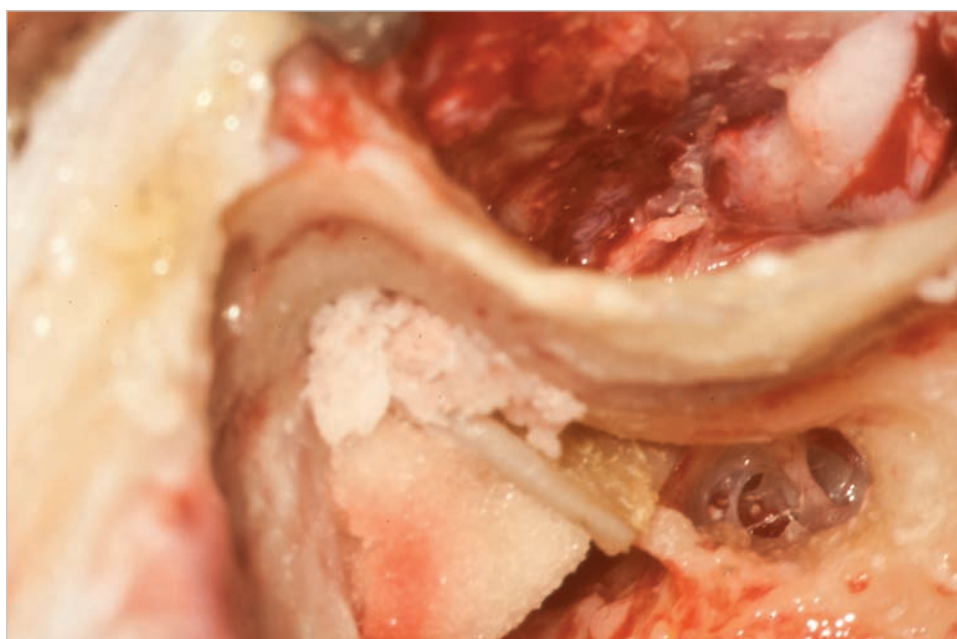


Fig. 6.49 Bone pate is applied between the cartilage and the posterior wall.



Fig. 6.50 The reconstructed scutum with bone paste is shown. The lateral process of the malleus is identified (*arrow*).

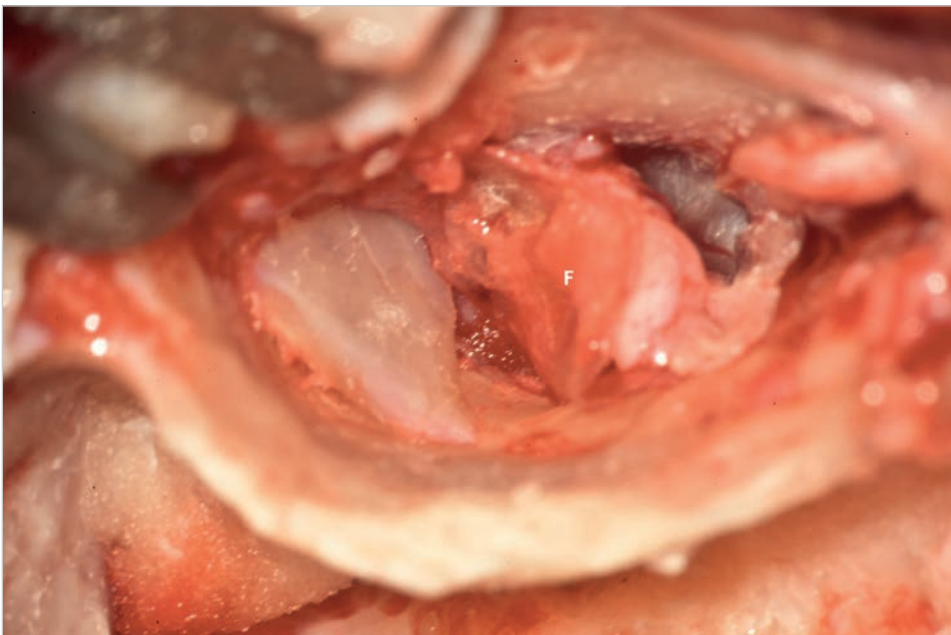


Fig. 6.51 The tympanomeatal flap is reflected inferiorly, and the temporalis fascia is grafted underlay. A very thin slice of cartilage is placed over the bone paste, and the reconstruction of the scutum is completed. F, fascia.

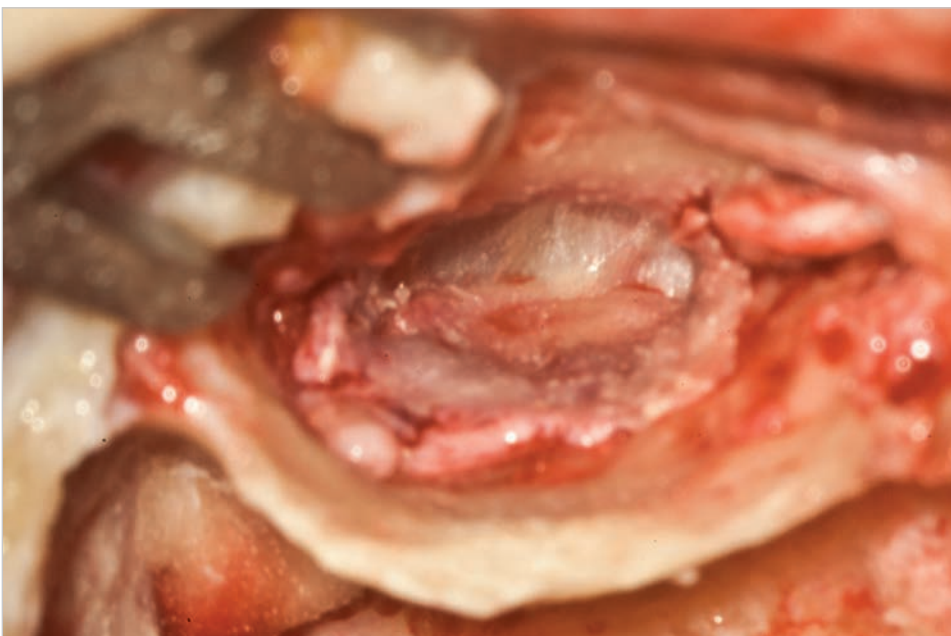


Fig. 6.52 The tympanomeatal flap is placed back with fascia, and the meatus is packed with Gelfoam.

Case 6.2 (Right Ear)

See ► Fig. 6.53, ► Fig. 6.54, ► Fig. 6.55, ► Fig. 6.56, ► Fig. 6.57, ► Fig. 6.58, ► Fig. 6.59, ► Fig. 6.60, ► Fig. 6.61, ► Fig. 6.62, ► Fig. 6.63, ► Fig. 6.64, ► Fig. 6.65, ► Fig. 6.66, ► Fig. 6.67, ► Fig. 6.68, ► Fig. 6.69.

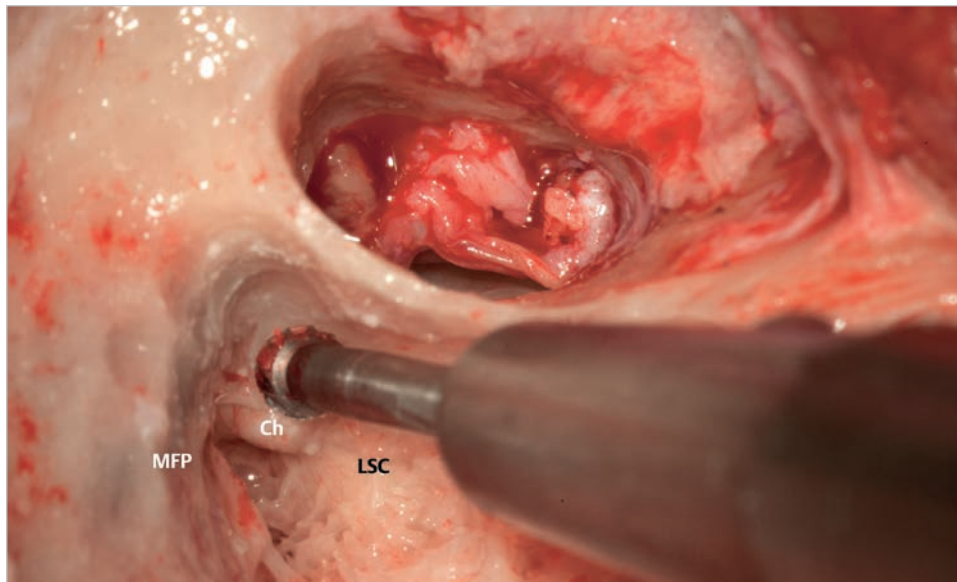


Fig. 6.53 A case of small epimesotympanic cholesteatoma in a child with a pneumatized mastoid is shown. A single stage canal wall up tympanoplasty, if possible, is planned. To gain access to the tympanic membrane, the bony meatus has already been calibrated after detaching the anterior meatal skin. A mastoidectomy revealed posterior end of the cholesteatoma in the attic. Ch, cholesteatoma; LSC, lateral semicircular canal; MFP, middle fossa plate.

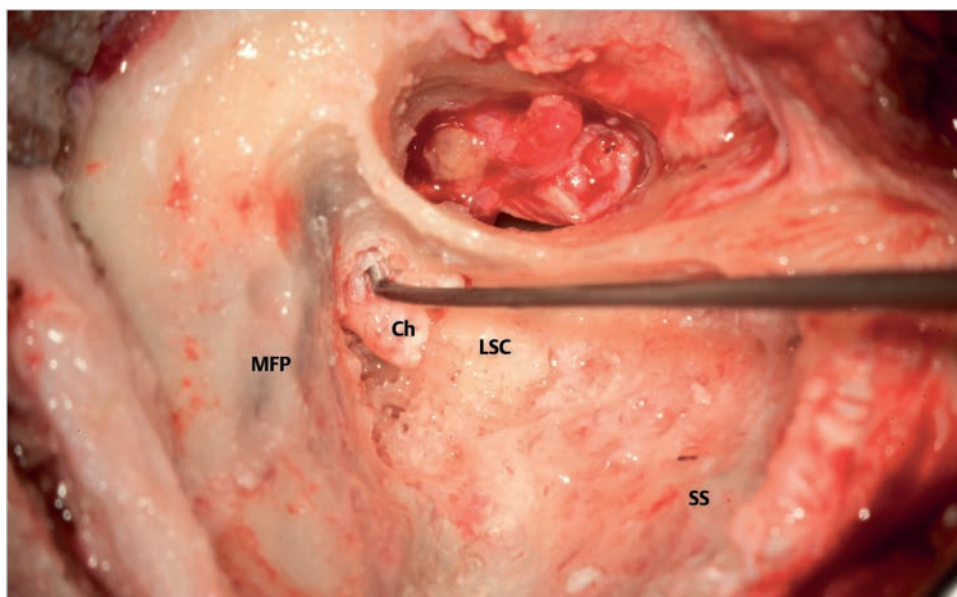


Fig. 6.54 The attic is further opened, and cholesteatoma in the attic is started to be dissected. Ch, cholesteatoma; LSC, lateral semicircular canal; MFP, middle fossa plate; SS, sigmoid sinus.

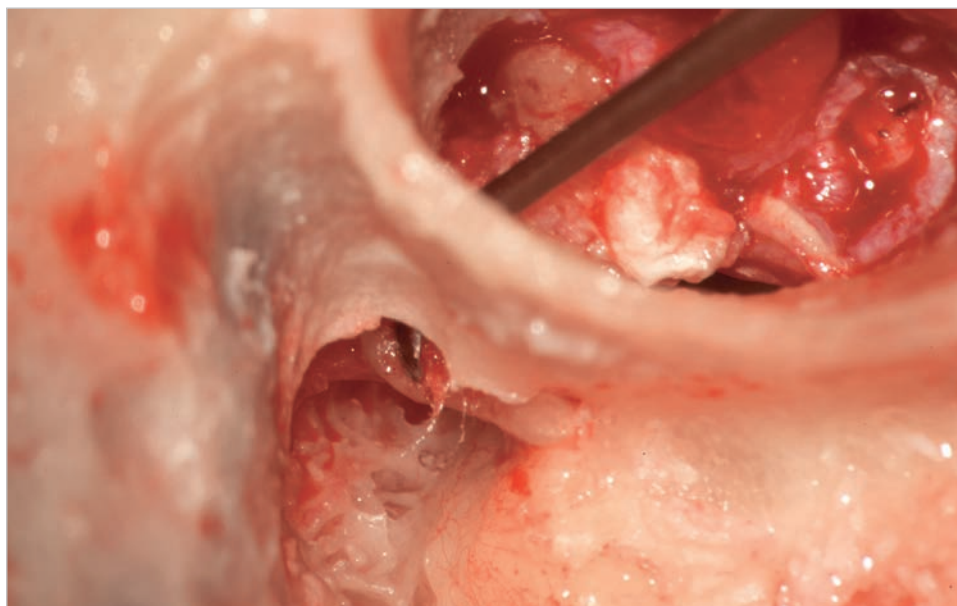


Fig. 6.55 The majority of the cholesteatoma is removed from the attic. The instrument is introduced from the bony erosion in the attic. Since the cholesteatoma did not reach the area medially to the ossicular chain and anteriorly to it, preservation of the ossicular chain is indicated.

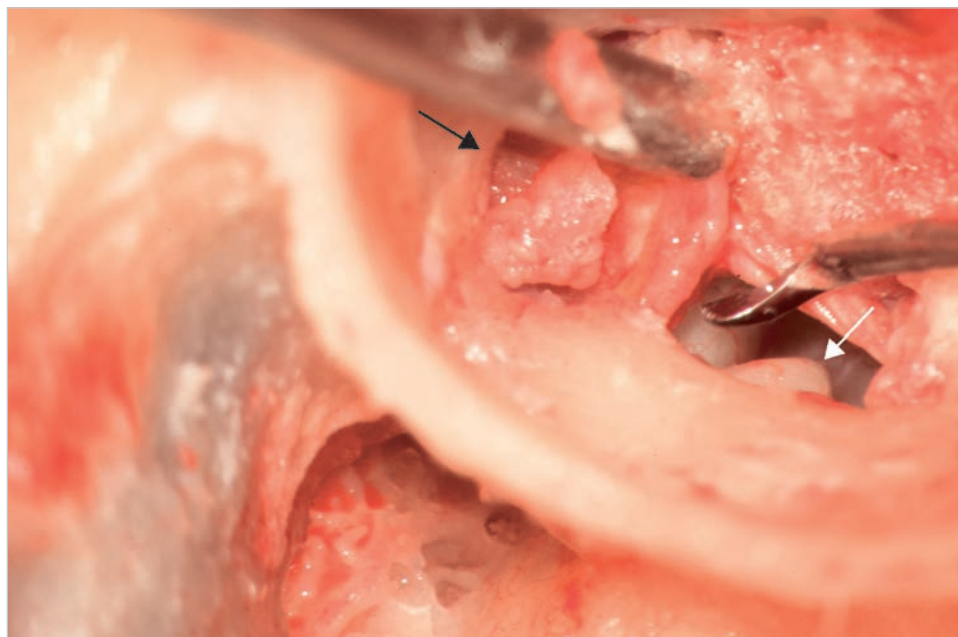


Fig. 6.56 The tympanomeatal flap is reflected anteriorly, and integrity of the incudostapedial joint (*white arrow*) is verified. An erosion served as an entrance of cholesteatoma is seen in the attic (*black arrow*).

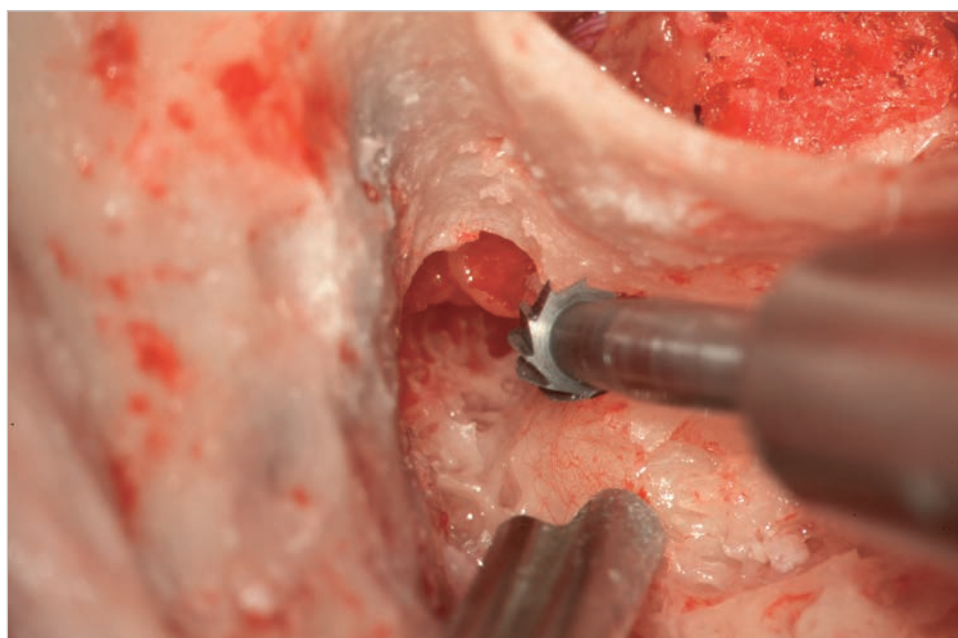


Fig. 6.57 The attic is further opened taking care not to touch the ossicular chain.

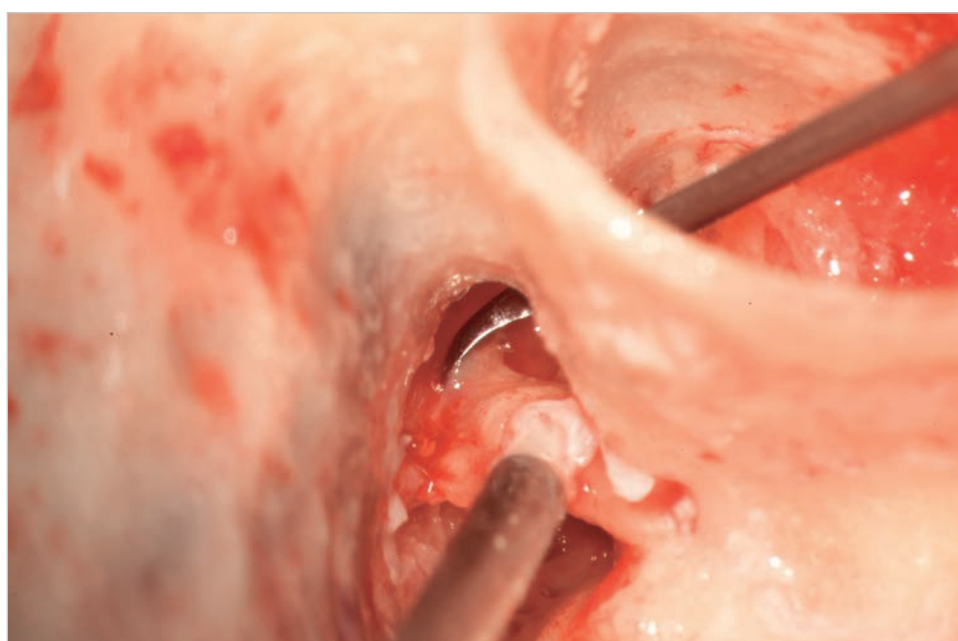


Fig. 6.58 Cholesteatoma is dissected from the lateral face of the ossicular chain in the attic using combined approach, introducing a microdissector from the meatus, and a suction tube from the mastoid.

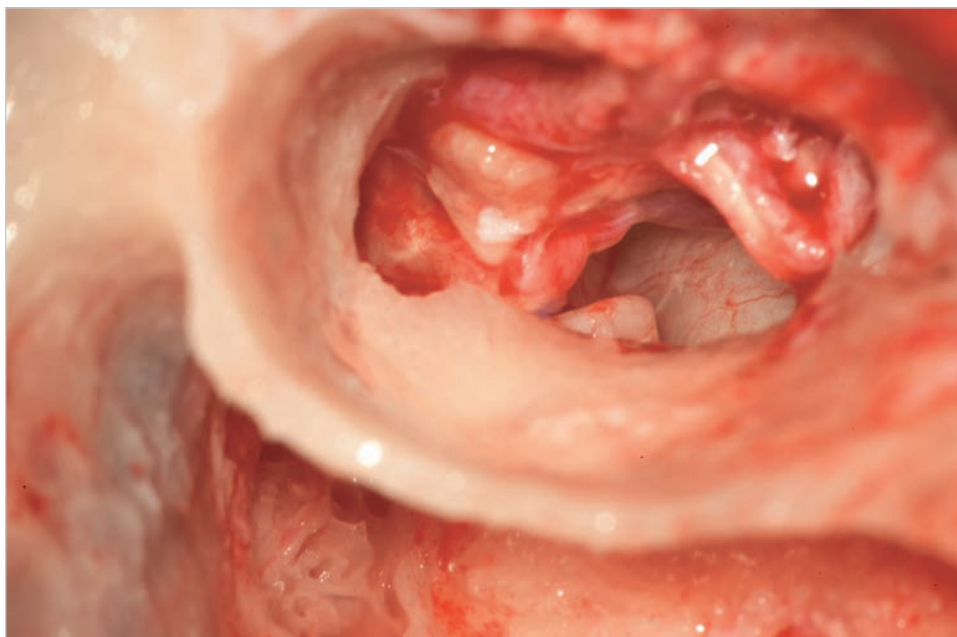


Fig. 6.59 The majority of the cholesteatoma is removed from the middle ear, except the small part goes posteriorly to the long process of the incus.

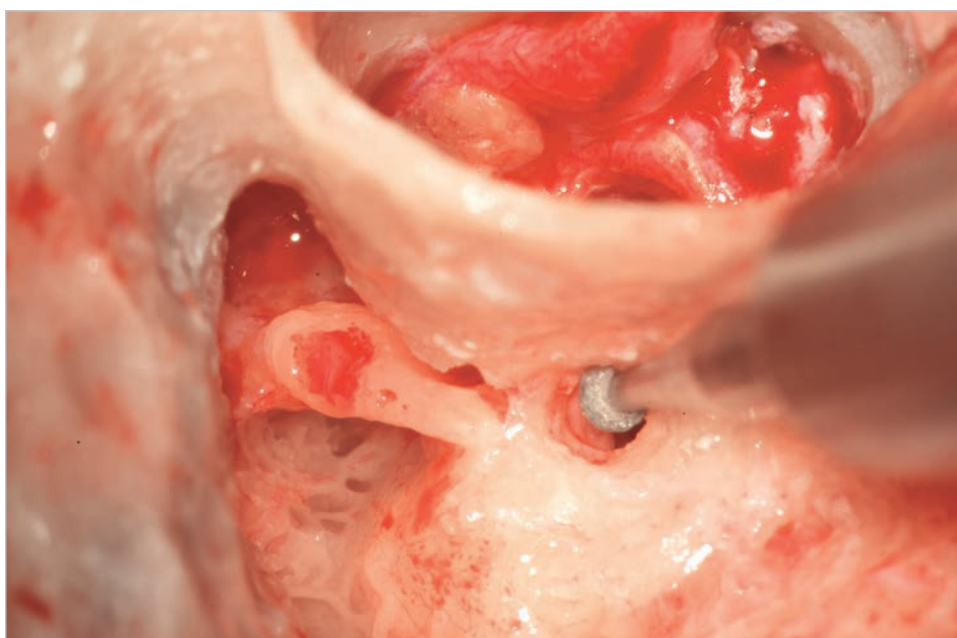


Fig. 6.60 To control the cholesteatoma located posterosuperior part of the tympanic cavity, a posterior tympanotomy is carried out taking care not to touch the short process of the incus, and not to damage the facial nerve. An erosion is seen in the body of the incus.

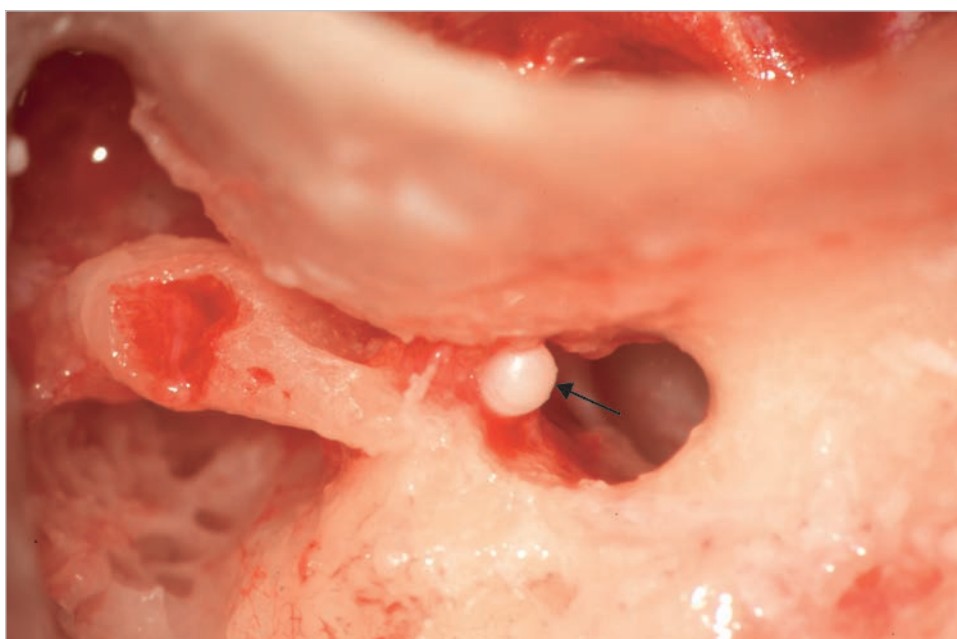


Fig. 6.61 Cholesteatoma located posteriorly to the long process of the incus to reach the facial recess is shown (arrow).

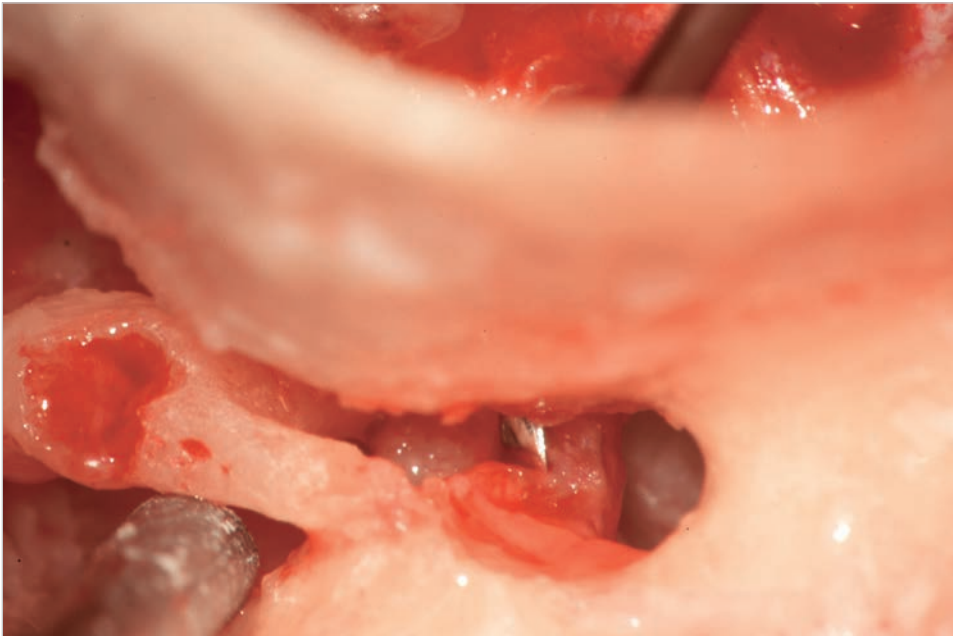


Fig. 6.62 The matrix covering the posterior crus of the stapes is dissected with a dissector introduced from the meatus.

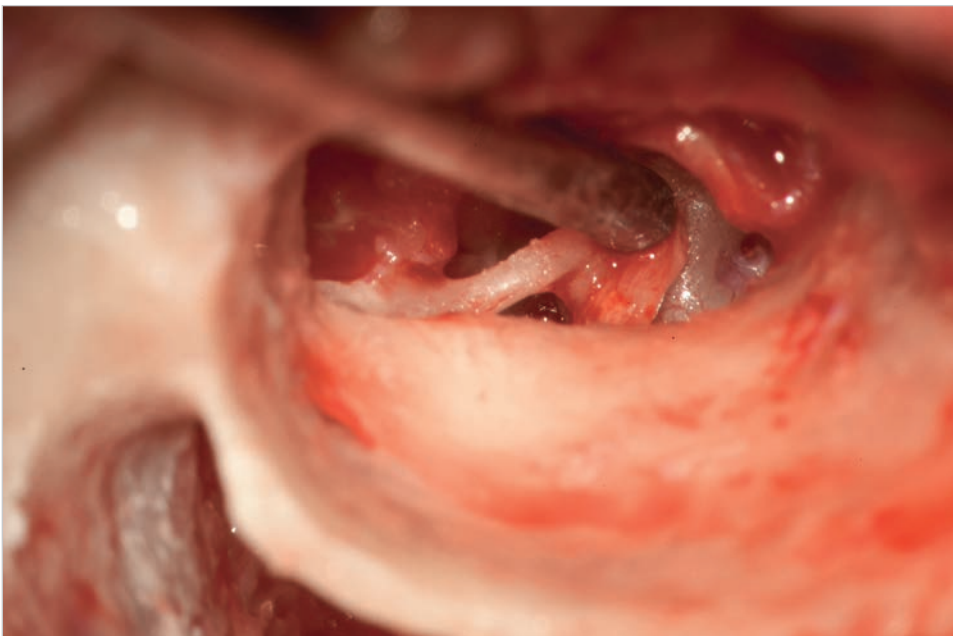


Fig. 6.63 The final piece of the cholesteatoma matrix is detached from the stapes through the meatus.

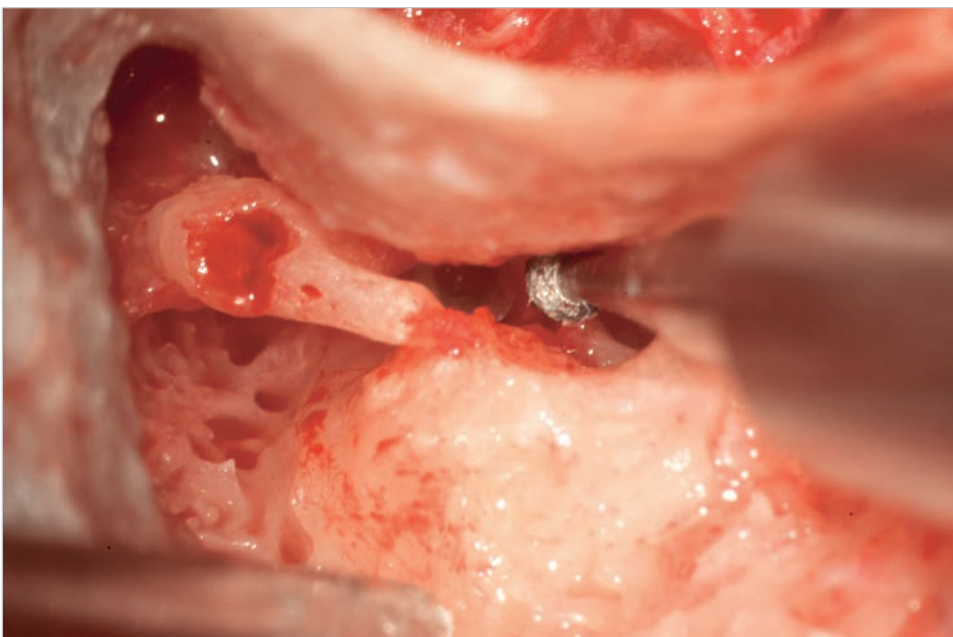


Fig. 6.64 The posterior tympanotomy is enlarged with a small diamond burr to verify absence of residual disease in the tympanic cavity.

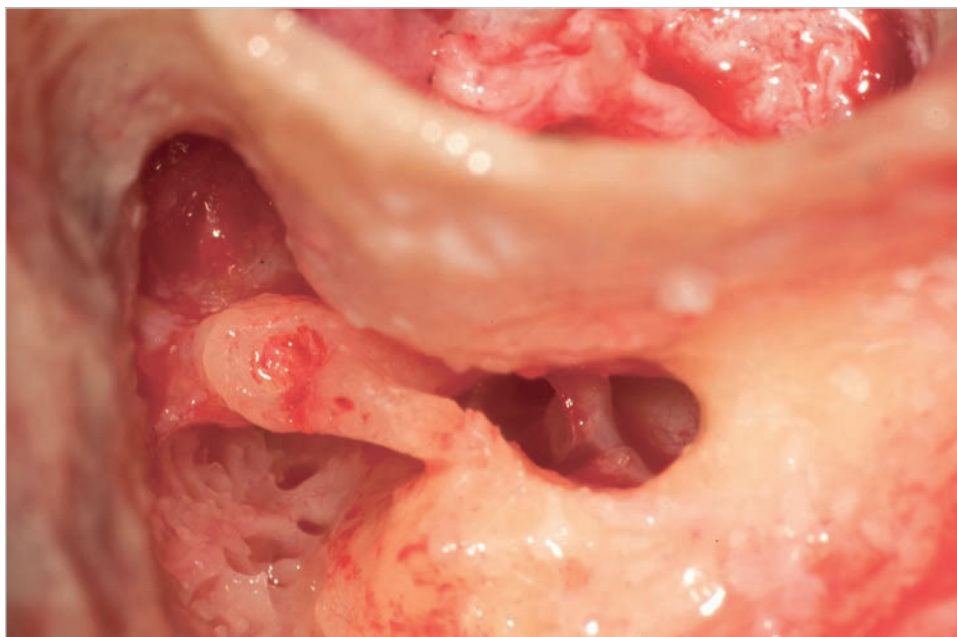


Fig. 6.65 Complete removal of the cholesteatoma from the middle ear is verified.

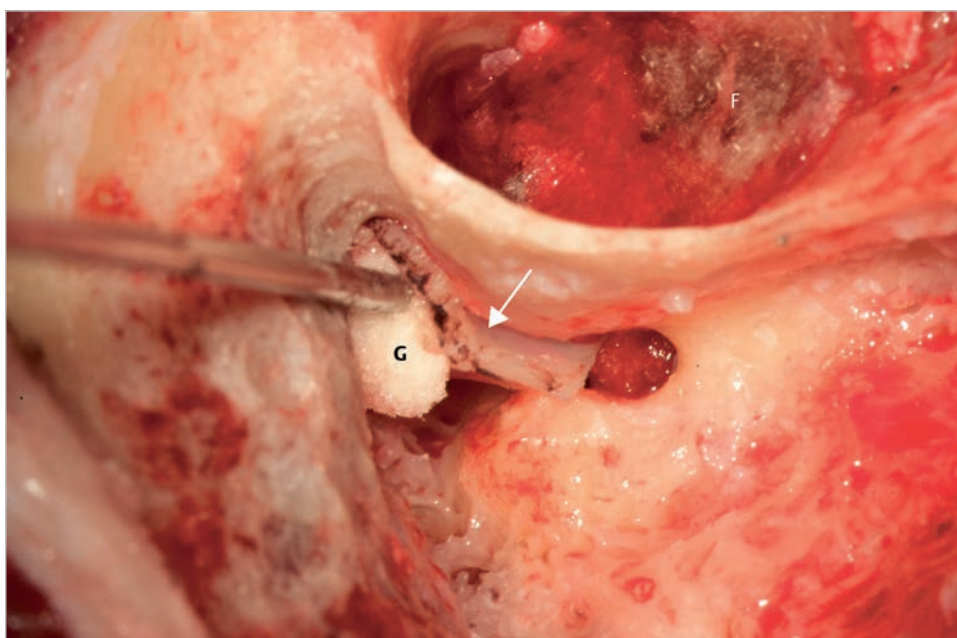


Fig. 6.66 A piece of temporalis fascia is grafted underlay, and reflected anteriorly. A piece of cartilage (*arrow*) is placed from the mastoid to close the epitympanic erosion, and to reinforce the posterosuperior quadrant. A large piece of Gelfoam is used to support the cartilage. F, fascia; G, Gelfoam.



Fig. 6.67 From the mastoid, bone passed is applied over the cartilage to close the epitympanic erosion. F, fascia.

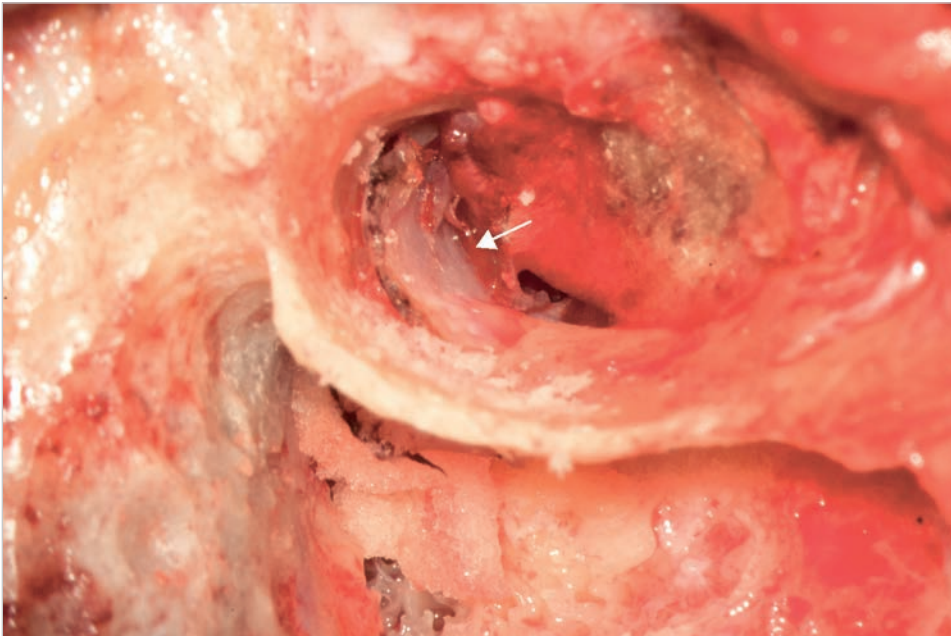


Fig. 6.68 The other thin piece of cartilage (*arrow*) is placed over the bone paste to reconstruct the bone erosion in the attic.

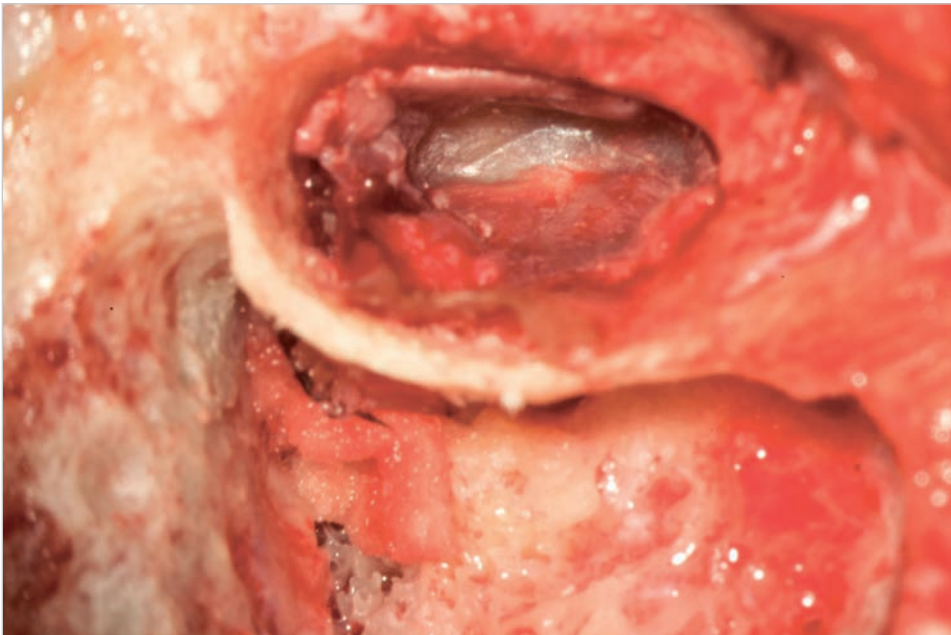


Fig. 6.69 The fascia and the tympanomeatal flap is replaced, and canal wall up tympanoplasty is accomplished.

Case 6.3 (Right Ear)

See ►Fig. 6.70, ►Fig. 6.71, ►Fig. 6.72, ►Fig. 6.73, ►Fig. 6.74, ►Fig. 6.75, ►Fig. 6.76, ►Fig. 6.77, ►Fig. 6.78, ►Fig. 6.79, ►Fig. 6.80, ►Fig. 6.81, ►Fig. 6.82, ►Fig. 6.83, ►Fig. 6.84, ►Fig. 6.85, ►Fig. 6.86, ►Fig. 6.87, ►Fig. 6.88, ►Fig. 6.89, ►Fig. 6.90, ►Fig. 6.91, ►Fig. 6.92, ►Fig. 6.93, ►Fig. 6.94, ►Fig. 6.95, ►Fig. 6.96, ►Fig. 6.97, ►Fig. 6.98, ►Fig. 6.99, ►Fig. 6.100, ►Fig. 6.101, ►Fig. 6.102, ►Fig. 6.103, ►Fig. 6.104, ►Fig. 6.105, ►Fig. 6.106, ►Fig. 6.107.

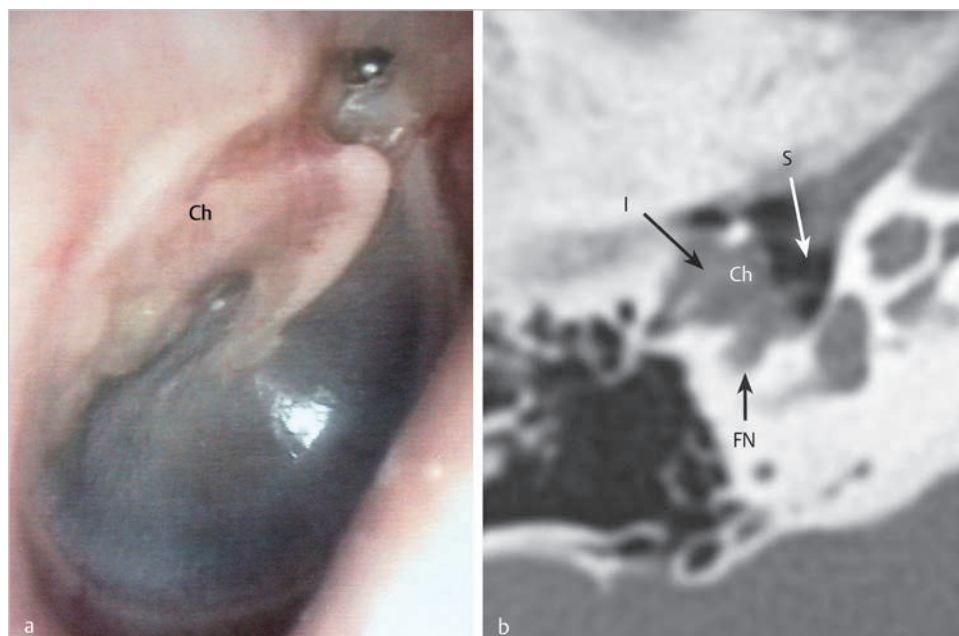


Fig. 6.70 (a, b) A case of small mesotympanic cholesteatoma treated with one-stage canal wall up tympanoplasty. On otoscopy, a cholesteatoma is seen in posterosuperior quadrant. The CT revealed its posterosuperior localization in the tympanic cavity, and absence of pathology in the well-pneumatized mastoid. The long process of the incus is eroded explaining preoperative conductive hearing loss. Ch, cholesteatoma; FN, facial nerve; I, incus; S, stapes.

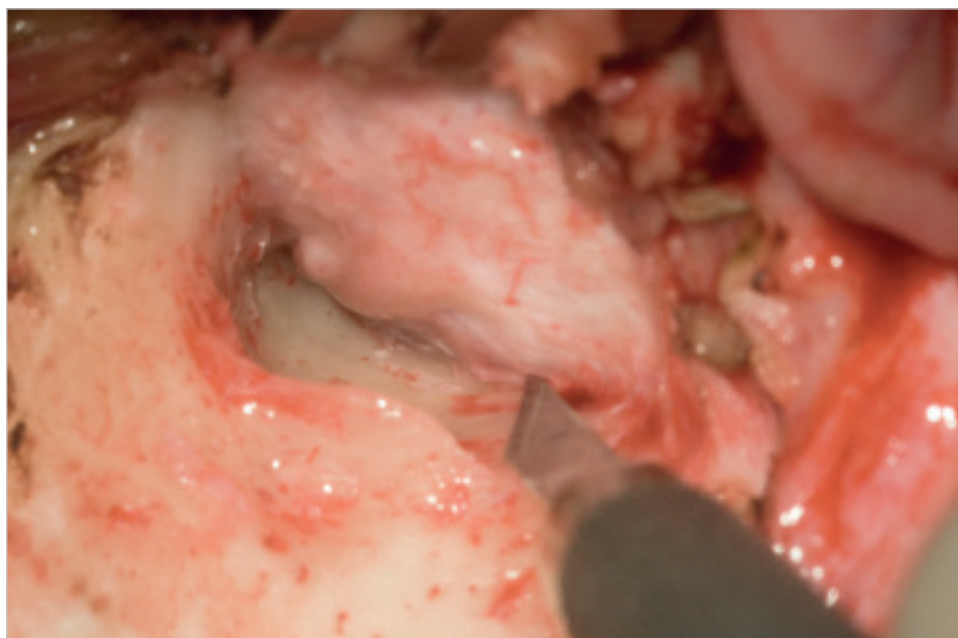


Fig. 6.71 Via retroauricular incision, the posterior meatal skin is detached from the bone. A circumferential incision is made to enter the external auditory canal.

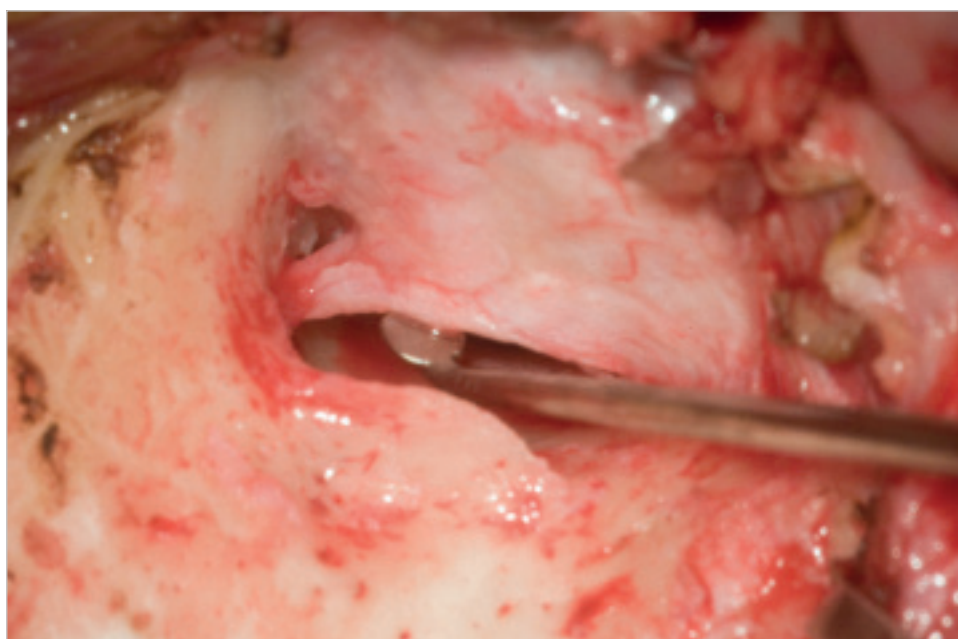


Fig. 6.72 After making two longitudinal cuts superiorly and inferiorly, the vascular strip is elevated with a microraspatory.



Fig. 6.73 The flap is secured with a self-retaining retractor, and the canal is opened widely.

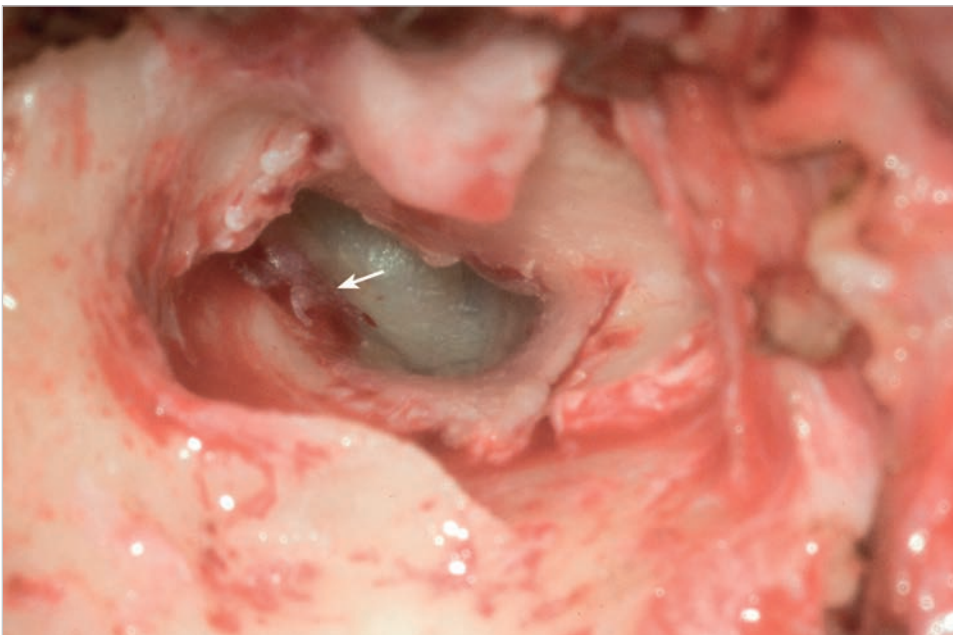


Fig. 6.74 To facilitate elevation of the tympanomeatal flap, a circumferential cut is made in the inferior meatal skin. An orifice of cholesteatoma is located in the posterosuperior quadrant (*arrow*).



Fig. 6.75 The meatal skin is elevated with a microraspatory. Great care should be taken not to tear it. To preserve the skin intact, it is better to keep the tip of the instrument touching to the bone during dissection, and not to work on the skin.



Fig. 6.76 After identifying the fibrous annulus (*black arrow*), the structure is detached from the bone, and the tympanic cavity is opened by incising tympanic mucosa located medially to the annulus. The chorda tympani nerve underneath the tympanic membrane is seen (*white arrow*).



Fig. 6.77 The tympanic cavity is opened. The cholesteatoma (*arrow*) in the posterosuperior quadrant covering the area of the incudostapedial joint (*white arrow*) is seen.

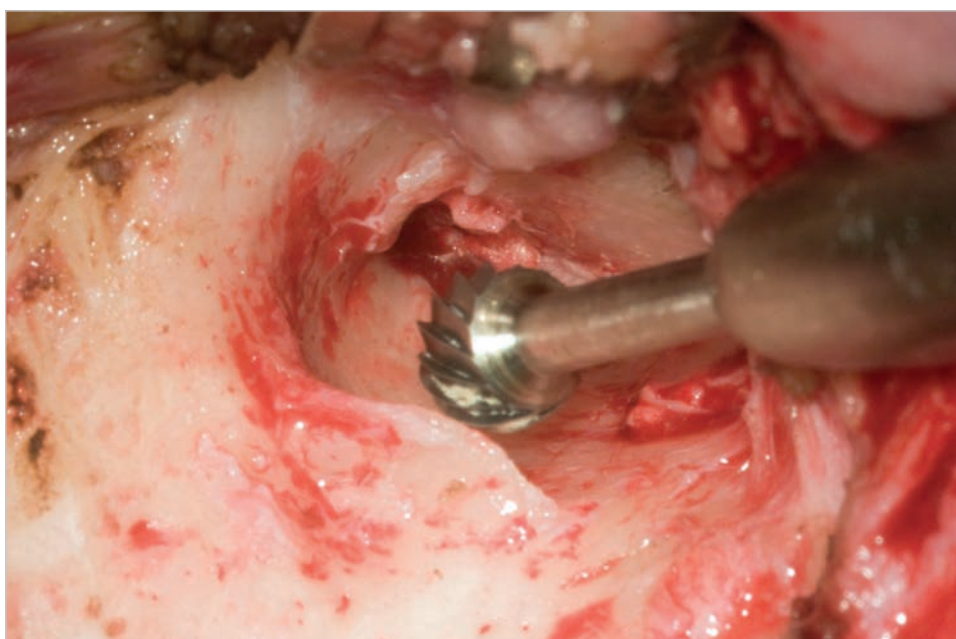


Fig. 6.78 The posterior meatal spine protruding from the posterior edge is removed first with a large cutting burr.

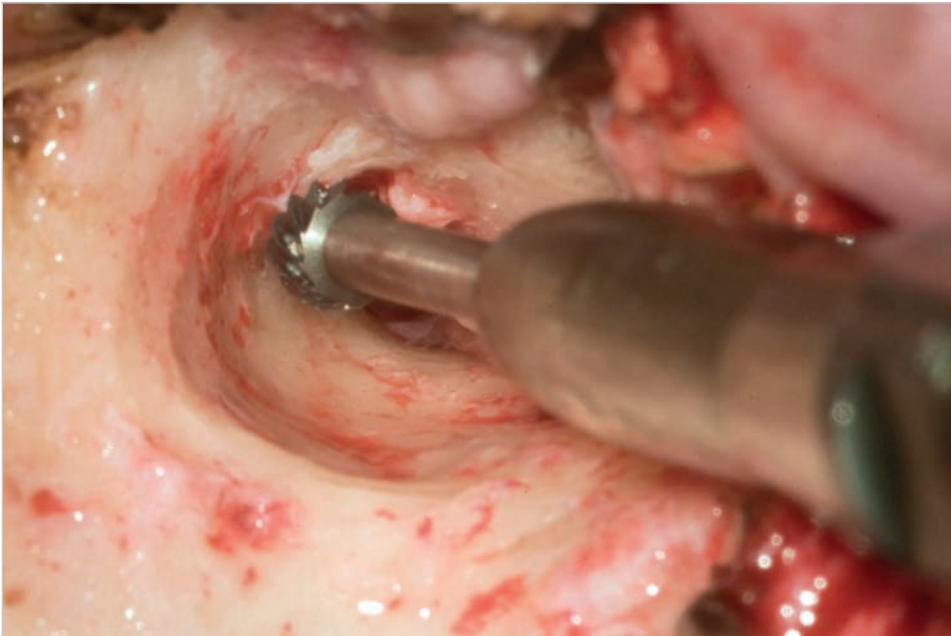


Fig. 6.79 The canaloplasty is advanced medially to visualize the tympanic membrane sufficiently.

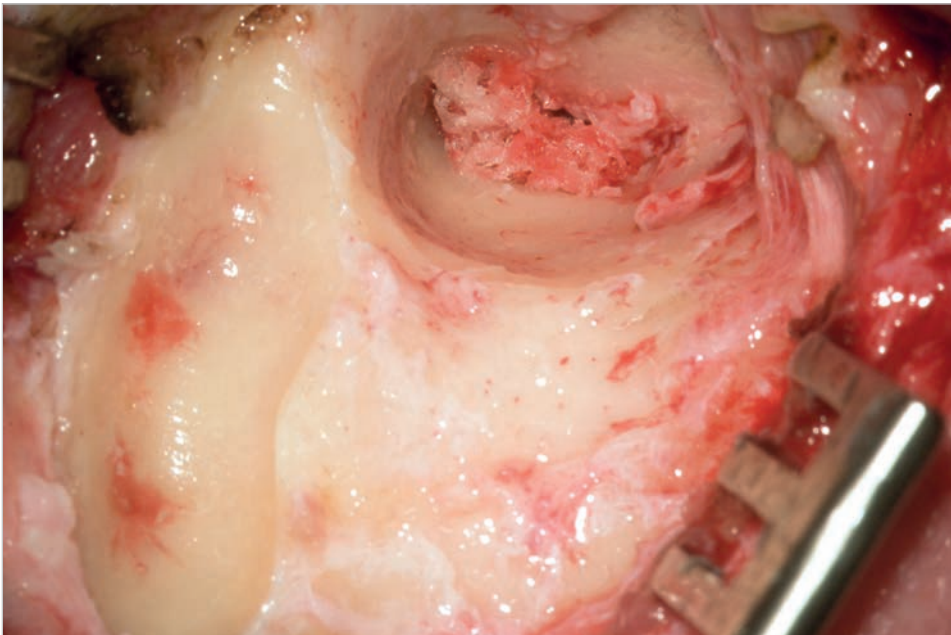


Fig. 6.80 The bony meatus is packed with a piece of cottonoid to achieve hemostasis. After exposing the surface of the mastoid sufficiently with the second self-retaining retractor, drilling is started from superior, to identify the middle fossa plate corresponding to the superior border of drilling by its pinkish color. Direction of the drilling in this area should be parallel to the middle fossa plate.

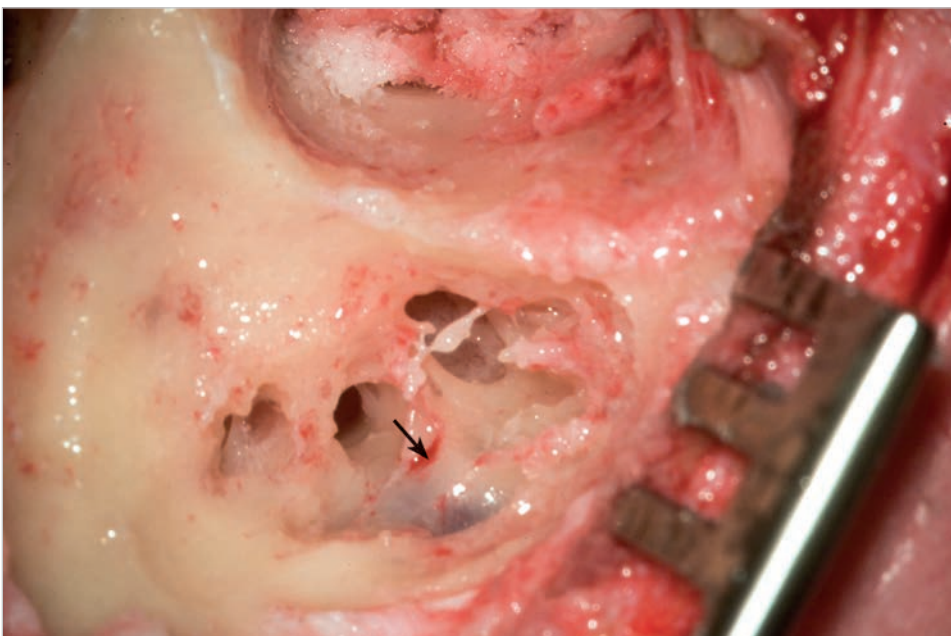


Fig. 6.81 The sigmoid sinus can be seen as a dark purple area with transparency (*arrow*). Except the cases with extensive pneumatization where developed retrosigmoid cells are present, the sinus usually corresponds to the posterior border of the drilling, and the posterior wall of the bony meatus defines the anterior border.

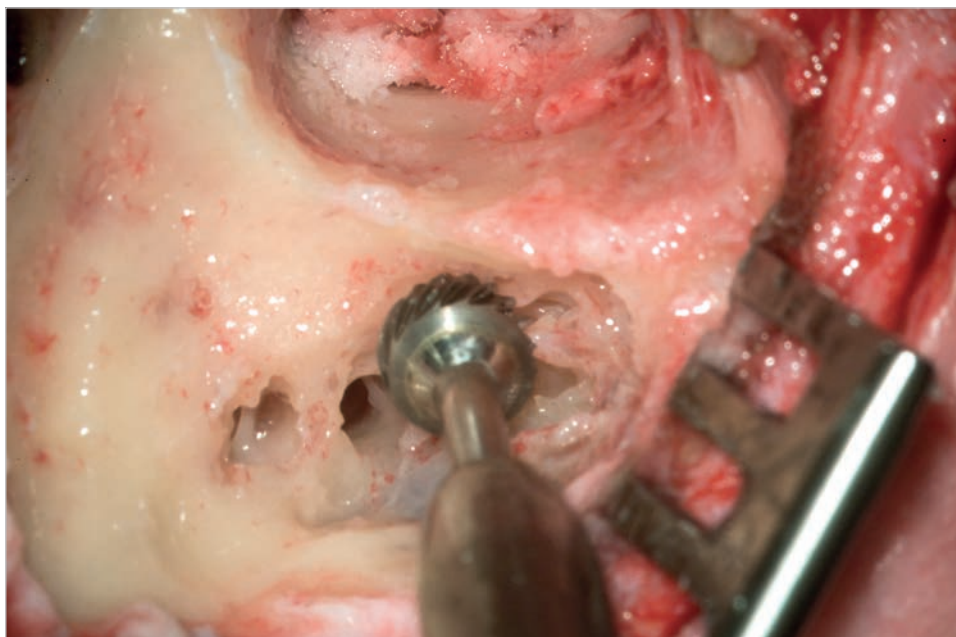


Fig. 6.82 In the early stage of mastoidectomy, drilling is carried out with a large cutting burr. Large cutting burrs allow faster bone removal, and easier identification of structures. If correctly conducted, no important structure in danger is present in the triangle formed with the sigmoid sinus posteriorly, the middle fossa plate superiorly, and the posterior meatal wall anteriorly. However, to avoid damaging these structures, direction of the drilling should be parallel to them.



Fig. 6.83 The opening of the cavity should be created large enough by removing bony overhangs in the edges, and the drilling should be advanced gradually toward the antrum without making a narrow hole. This allows the surgeon to obtain saucerized cavity that is safer to manage.

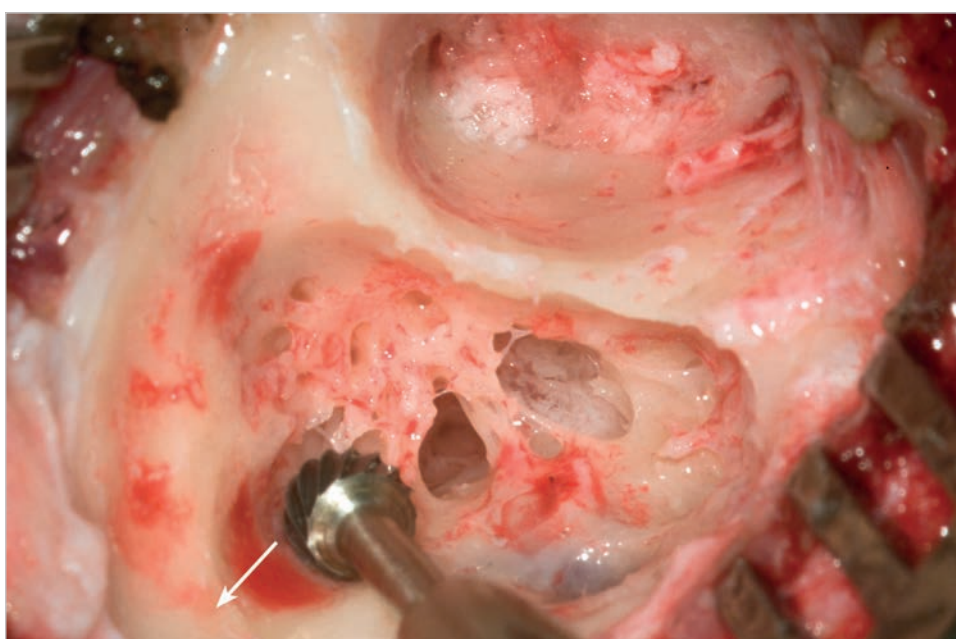


Fig. 6.84 The sinodural angle is opened. The drilling in this area should be conducted from medial to lateral (*arrow*).

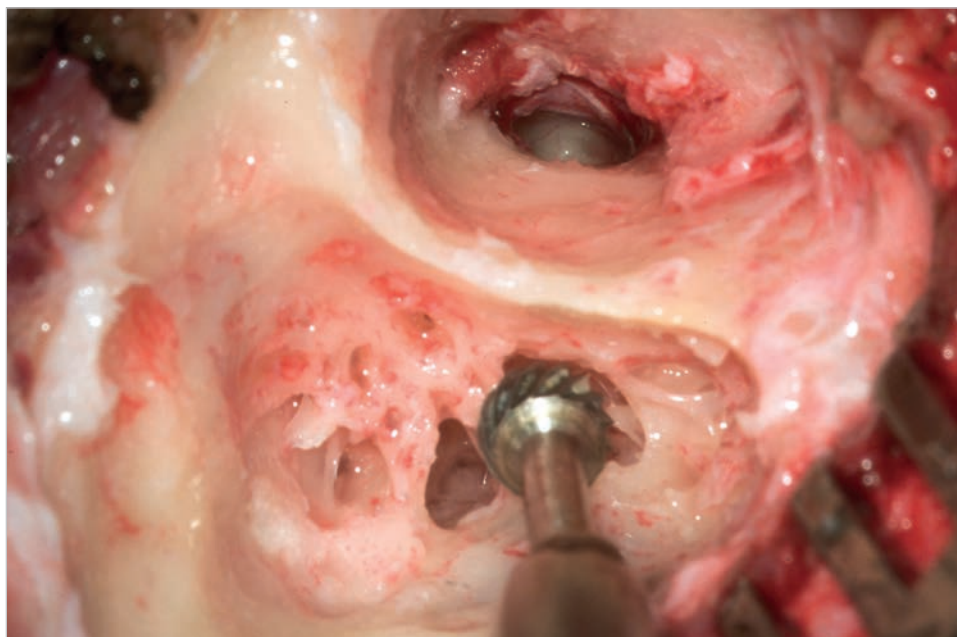


Fig. 6.85 The area of the mastoid tip is drilled with a large cutting burr.

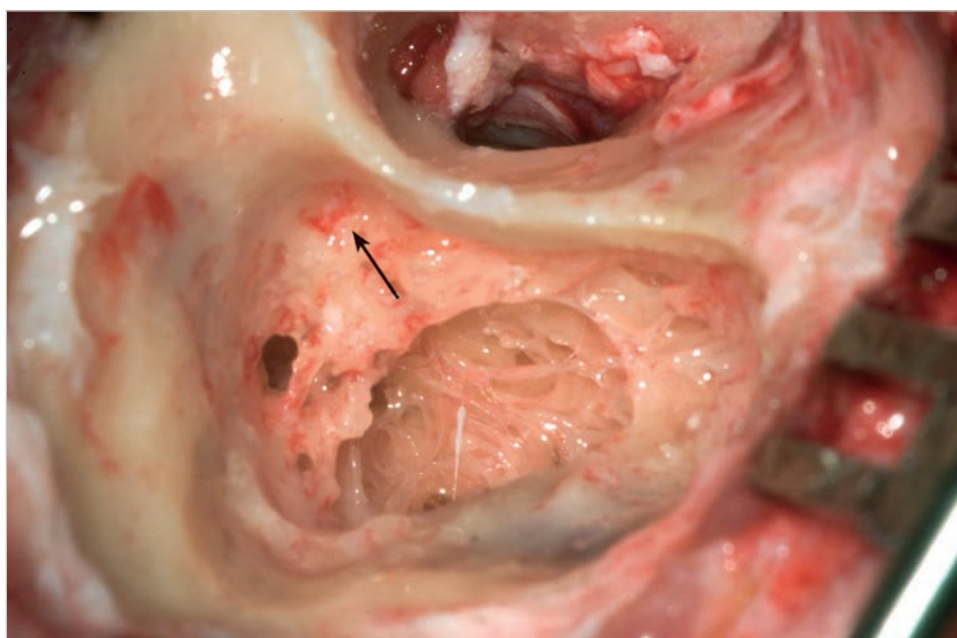


Fig. 6.86 The inferior part of the antrum is opened. Note that the cavity is saucerized, and the drilling is advanced medially without digging a narrow hole. To remove the bone covering the aditus, direction of the drill track should be from medial to lateral (*arrow*) to avoid inadvertent contact to the ossicular chain.

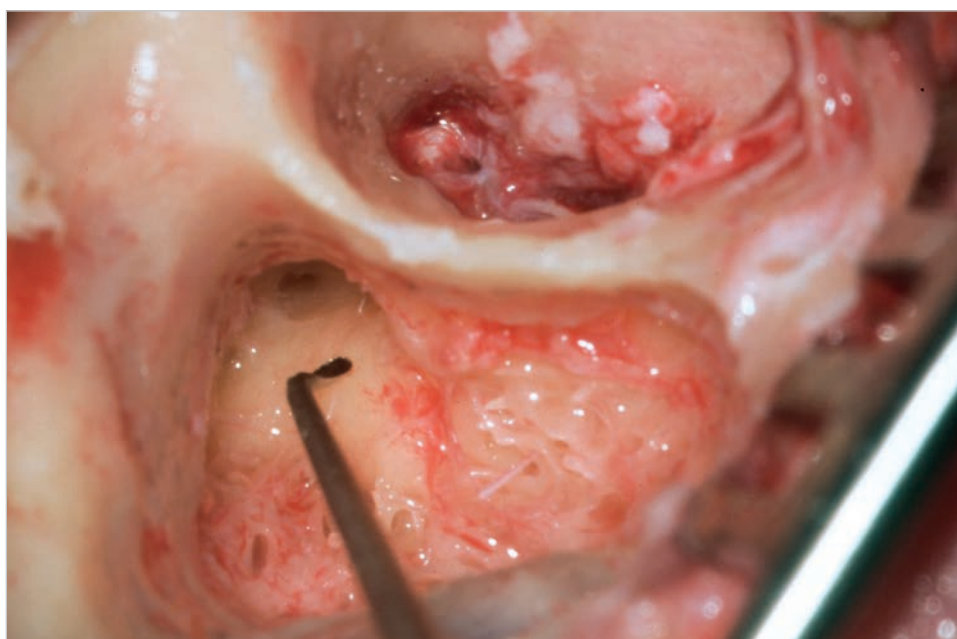


Fig. 6.87 Removal of the bone covering the superior part of the antrum exposed the eminence of the lateral semicircular canal that is pointed with the instrument. No cholesteatoma is seen in the antrum.



Fig. 6.88 Thickness of the posterior bony wall is indicated with two instruments. To visualize the posterosuperior portion of the tympanic cavity where the cholesteatoma is located, the bone should be thinned sufficiently.

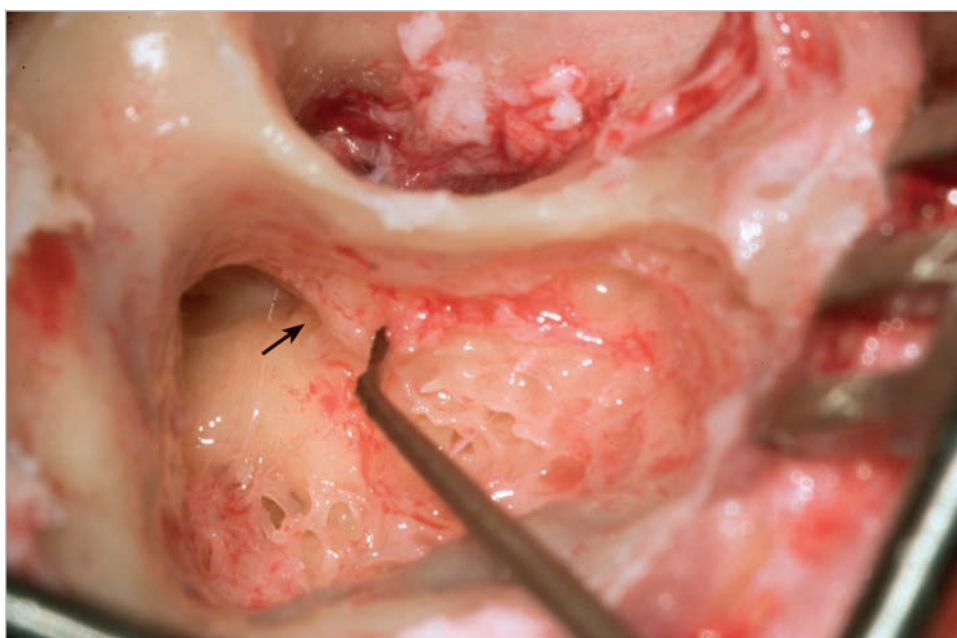


Fig. 6.89 The area to be drilled is indicated. Thick bone just posteroinferior to the fossa incudis (*arrow*) accommodating the short process of the incus should be removed to open the facial recess.

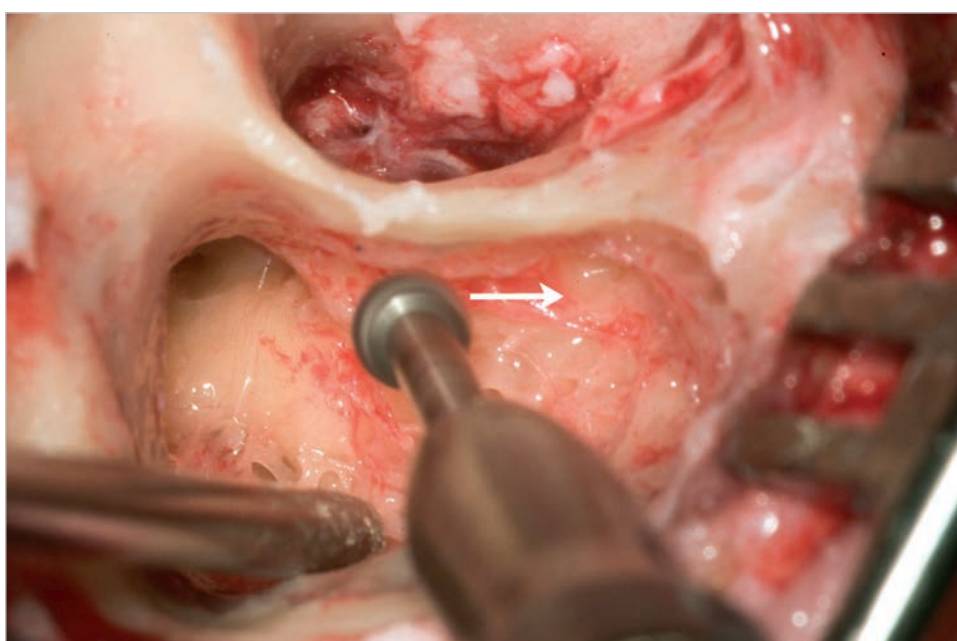


Fig. 6.90 In this particular case, since the incudostapedial joint is eroded by cholesteatoma, it is not dangerous to touch the incus with the bur. However, if integrity of the chain is preserved or the surgeon is not sure of the status, the drill should be moved from superior to inferior (*arrow*) in this area to avoid contact to the chain. Simultaneously, direction of the movement is parallel to the facial nerve, and reduces risk to damage the nerve.

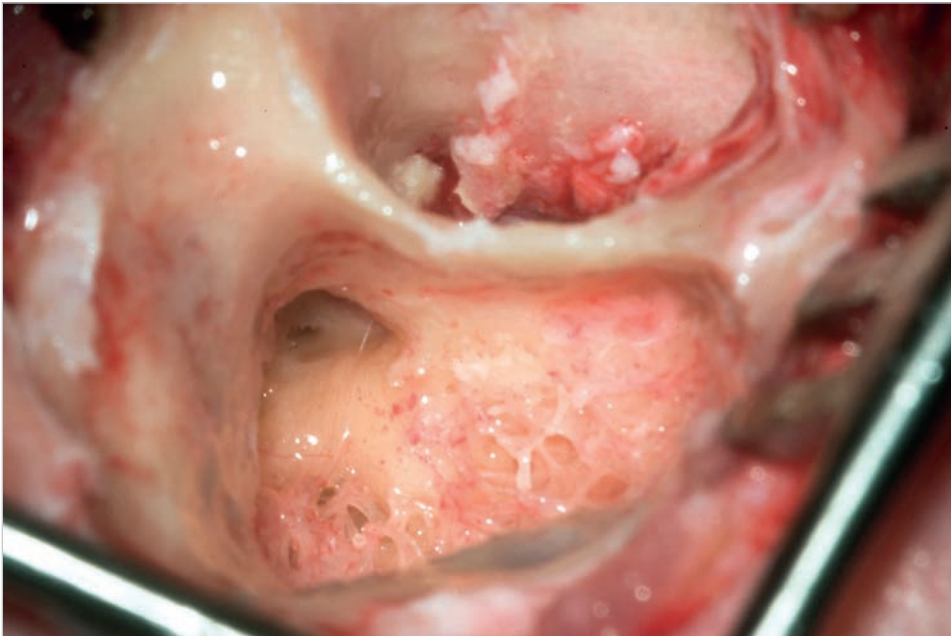


Fig. 6.91 The medial end of the posterior wall is thinned.

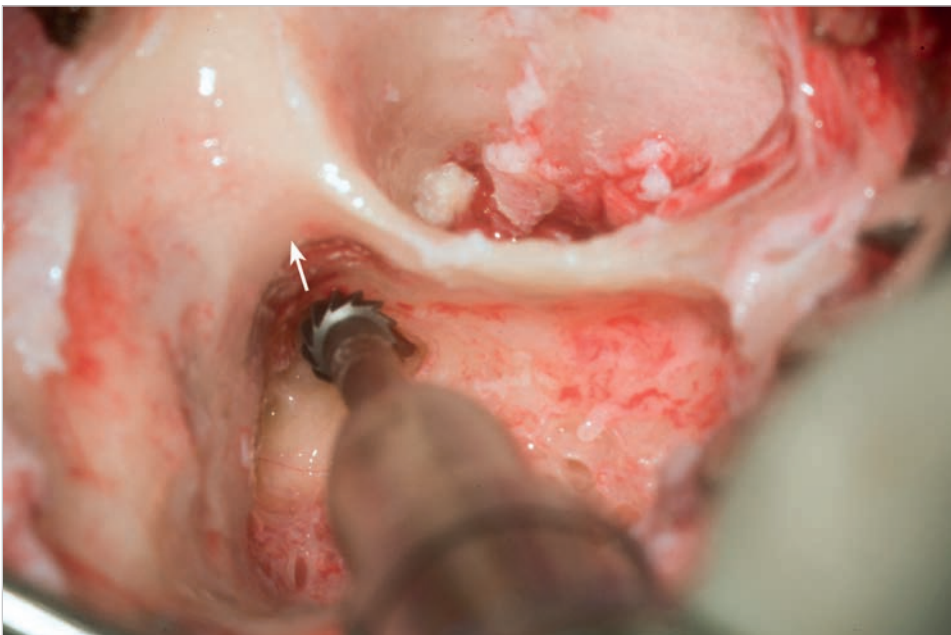


Fig. 6.92 The drilling is advanced anteriorly, taking care not to touch the ossicular chain. The drill should be moved from medial to lateral (*arrow*). In addition, to open the aditus ad antrum, it is better not to follow the posterior meatal wall but to follow the tegmen first, since the short process of the incus is located inferiorly.

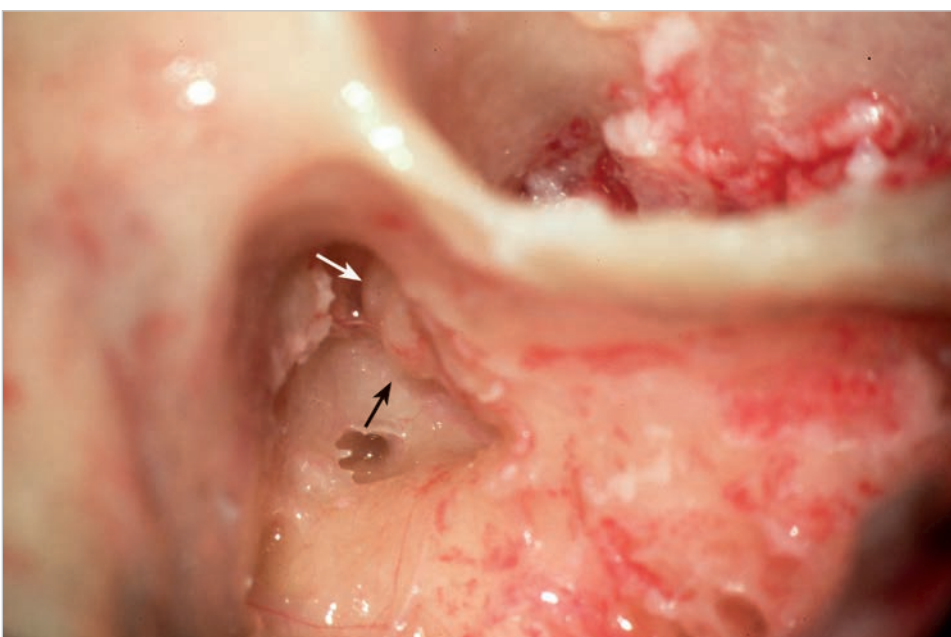


Fig. 6.93 To avoid damaging the ossicular chain, early identification is important. The bed is rotated away from the surgeon, and the area is seen from posterior. In this picture, the head of the malleus (*white arrow*) and the body of the incus (*black arrow*) are visualized. Removal of the bone near the ossicular chain can be carried out with a small burr, with the movement parallel to the chain, or from medial to lateral. The bone can be removed with a curette.



Fig. 6.94 Cholesteatoma on the lateral face of the incus is pushed inferiorly toward the tympanic membrane with a small cottonoid.

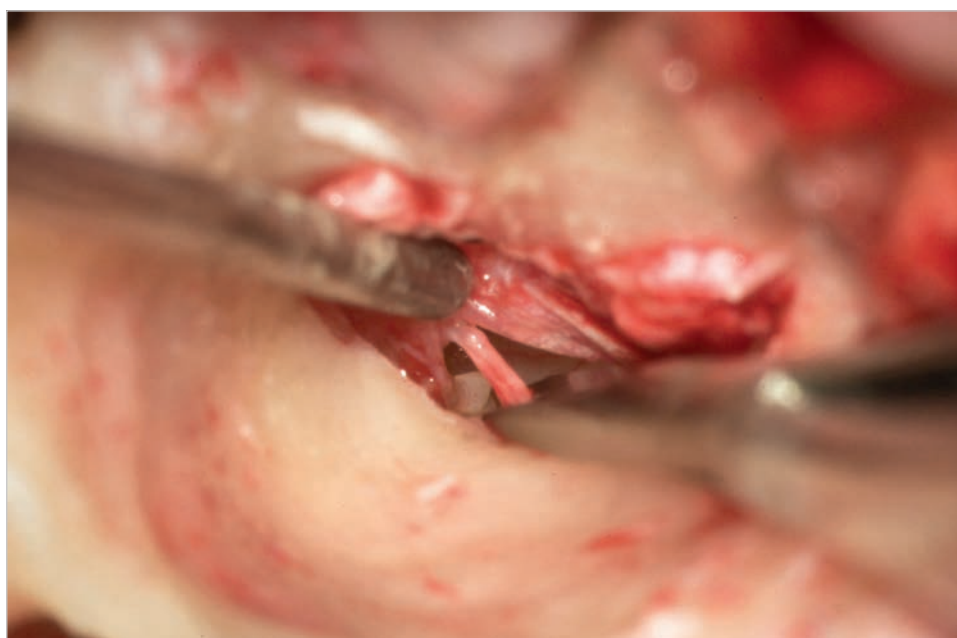


Fig. 6.95 From the external auditory canal, the chorda tympani nerve involved in the cholesteatoma is cut.



Fig. 6.96 The cholesteatoma is detached from the incus, and the incudostapedial joint is clearly seen (*arrow*). The long process of the incus is eroded, and a cicatricial tissue connects its tip with the body of the incus.

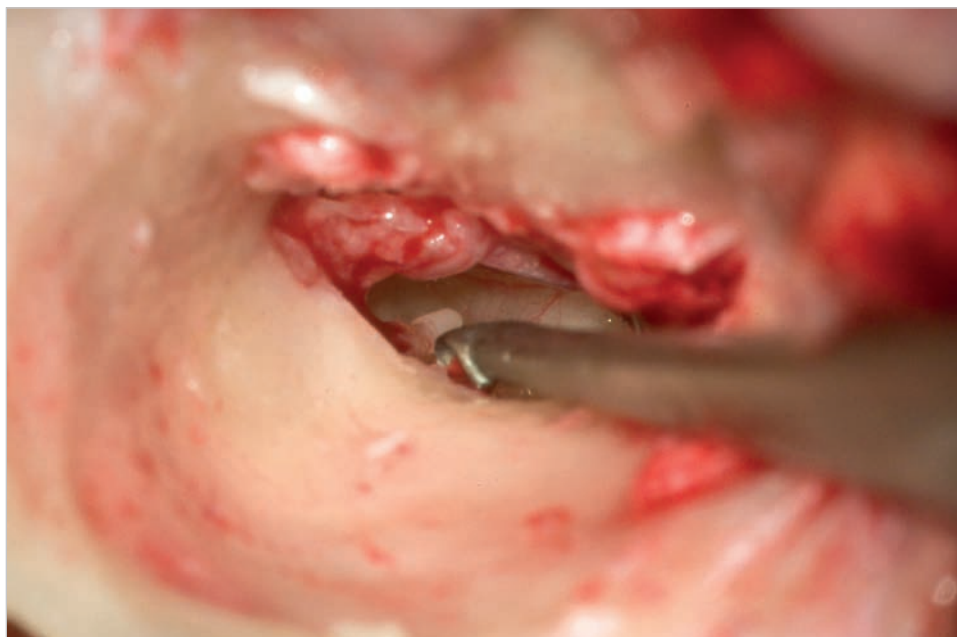


Fig. 6.97 A small atticotomy is performed to enlarge the access to the stapes.



Fig. 6.98 The connective tissue connecting the body of the incus with the remnant of the long process is cut with microscissors.



Fig. 6.99 The incus is taken out from the mastoid with some soft tissue adherent to the long process.



Fig. 6.100 The removed incus is shown. The long process of the incus is eroded (*arrow*).

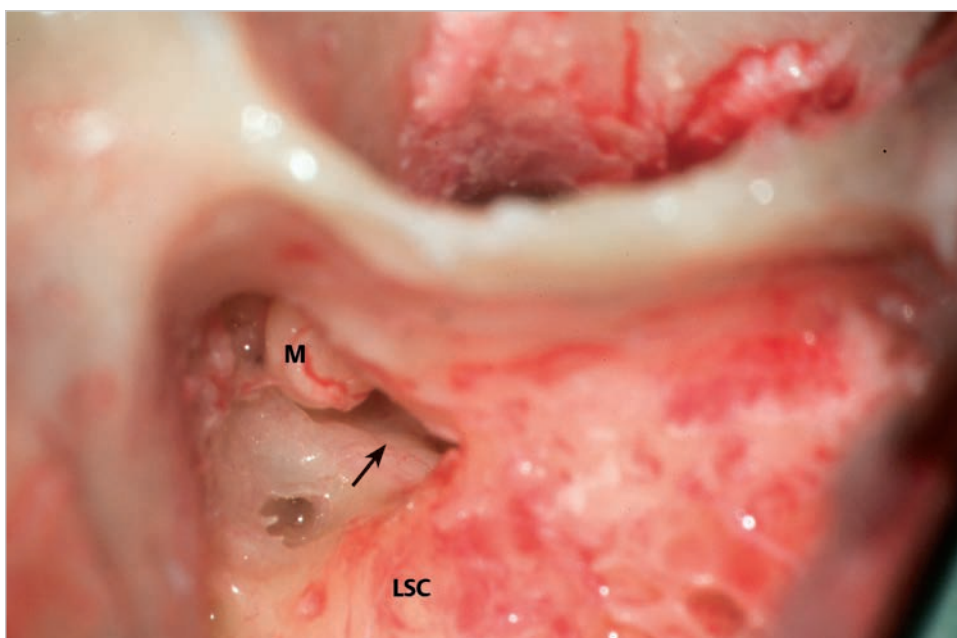


Fig. 6.101 Through the posterior atticoantrostomy, the head of the malleus (M) and the facial nerve (*arrow*) is seen. LSC, lateral semicircular canal.

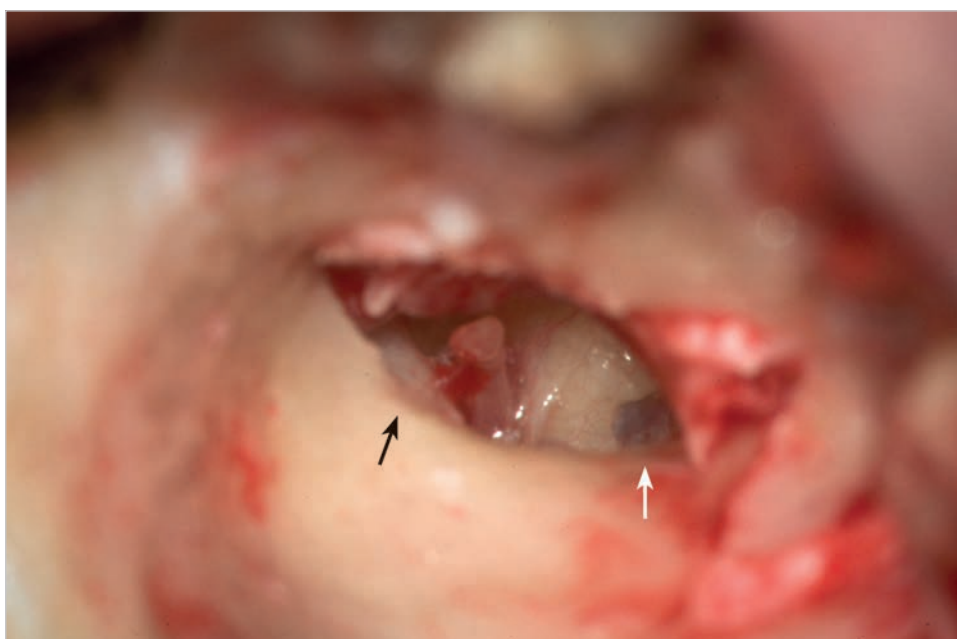


Fig. 6.102 The round window membrane (*white arrow*) is located inferiorly, and the facial nerve (*black arrow*) runs superiorly to the stapes.

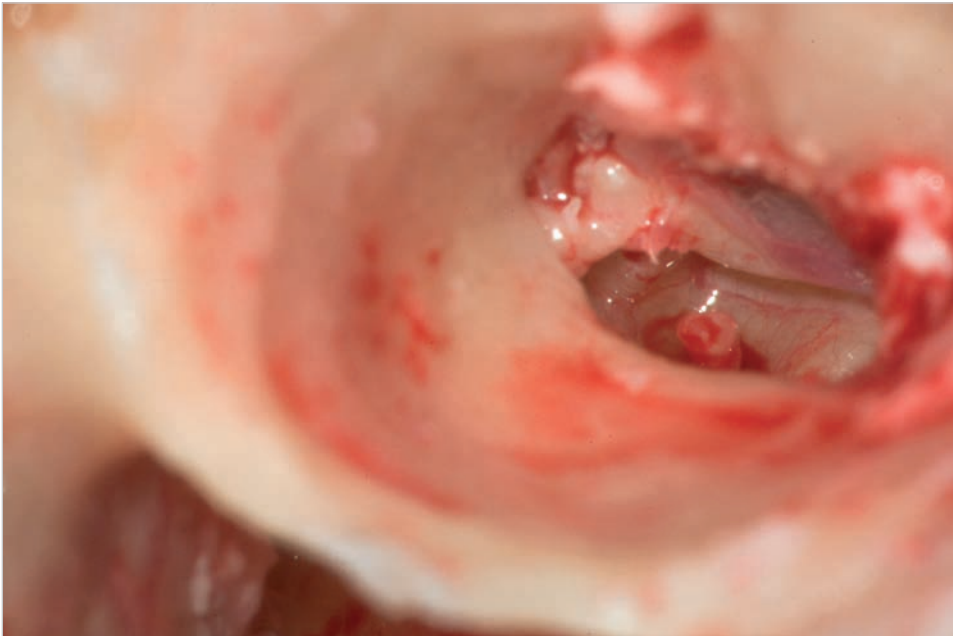


Fig. 6.103 Relationships between the malleus and the stapes is shown. The posterosuperior part of the tympanic membrane is removed with cholesteatoma.



Fig. 6.104 A thick small piece of cartilage is introduced into the tympanic cavity, and placed over the stapes.



Fig. 6.105 The cartilage is arranged in such a way that the anterior part of it has contact with the medial face of the manubrium of the malleus (arrow), expecting sound transmission. The cartilage is supported by small pieces of Gelfoam from medial. The second surgery may not be planned if the patient hears well postoperatively.

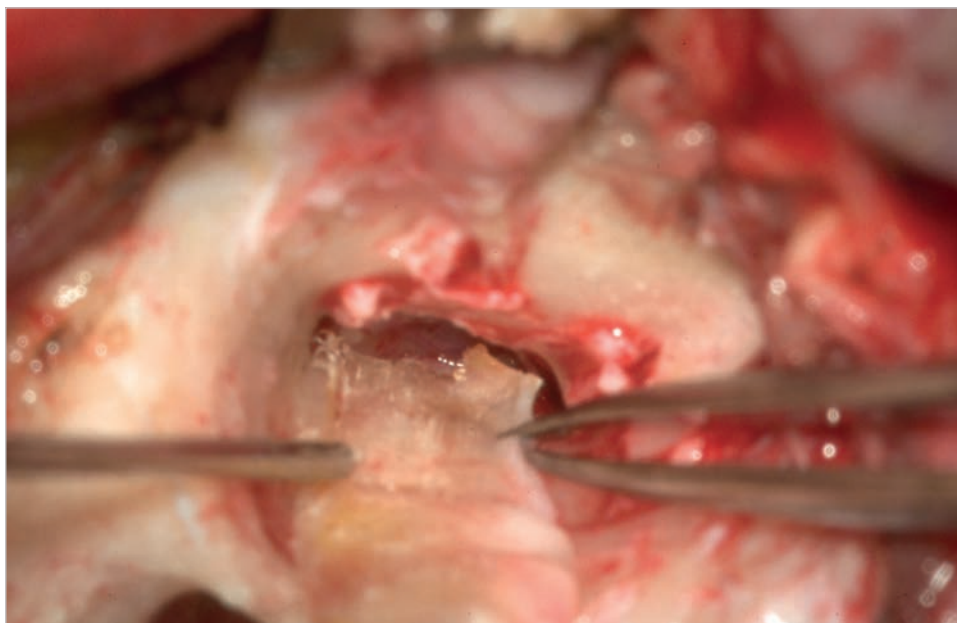


Fig. 6.106 A piece of temporalis fascia is grafted over the cartilage, to completely close the defect of the tympanic membrane.



Fig. 6.107 The tympanomeatal flap is replaced over the fascia. The meatus and the cavity are packed with pieces of Spongel, and the wound is closed in three layers. Since the majority of the mucosa remained in this surgery, Silastic sheeting is not required.

Case 6.4 (Right Ear)

See ► Fig. 6.108, ► Fig. 6.109, ► Fig. 6.110, ► Fig. 6.111, ► Fig. 6.112, ► Fig. 6.113, ► Fig. 6.114, ► Fig. 6.115, ► Fig. 6.116, ► Fig. 6.117, ► Fig. 6.118, ► Fig. 6.119, ► Fig. 6.120, ► Fig. 6.121, ► Fig. 6.122, ► Fig. 6.123, ► Fig. 6.124, ► Fig. 6.125, ► Fig. 6.126, ► Fig. 6.127, ► Fig. 6.128, ► Fig. 6.129.

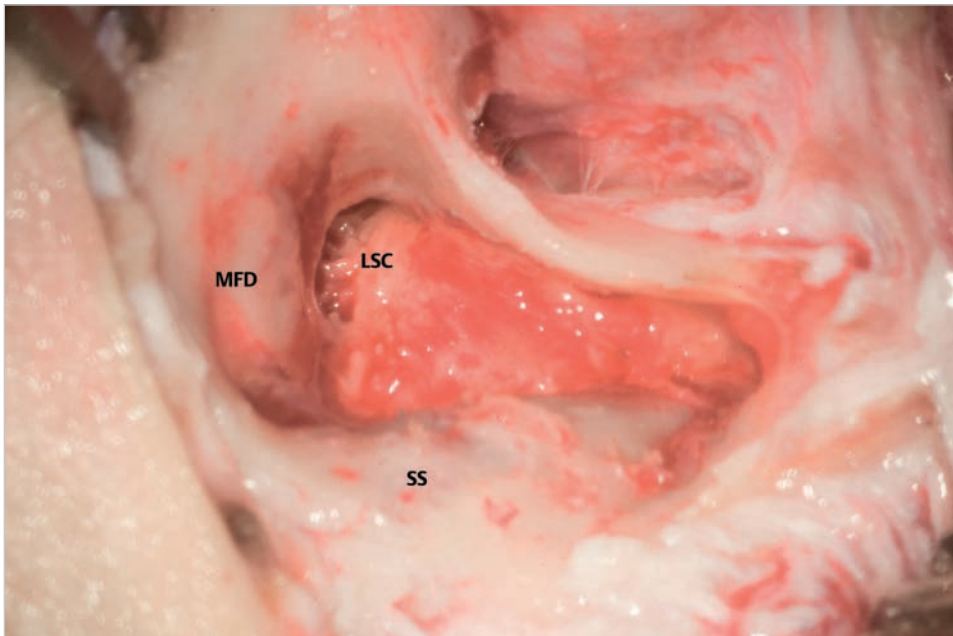


Fig. 6.108 A case of small cholesteatoma in the posterosuperior quadrant with erosion of the long process of the incus is shown. A staged canal wall up tympanoplasty is planned. To gain maximum access to the mastoid, the posterior canal wall is thinned, and the middle fossa dura and the sigmoid sinus are skeletonized. The eminence of the lateral semicircular canal is seen. LSC, lateral semicircular canal; MFD, middle fossa dura; SS, sigmoid sinus.

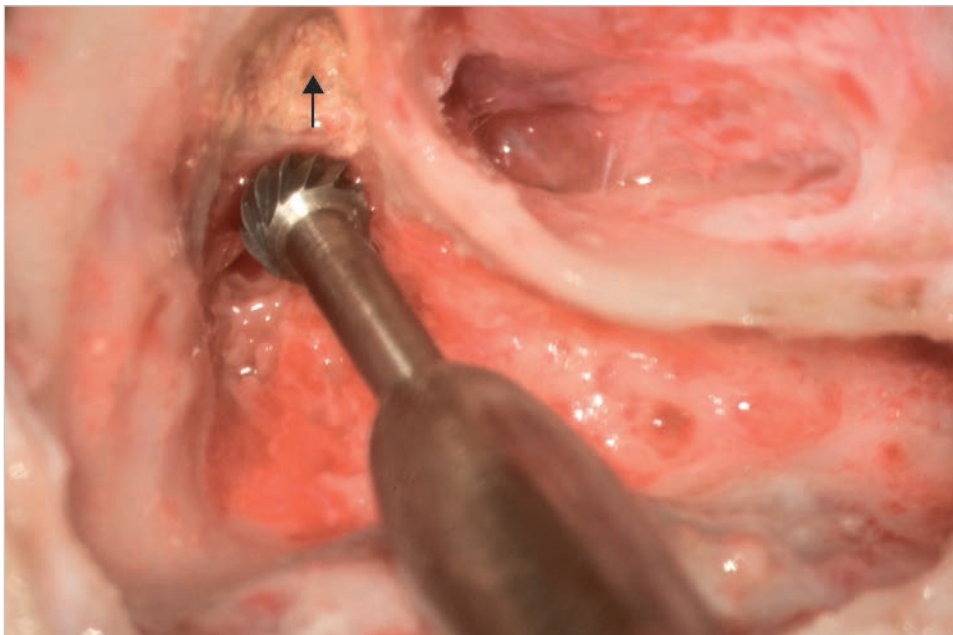


Fig. 6.109 The mastoidectomy is advanced anteriorly to open the attic with a small cutting burr. Care should be taken not to touch the ossicular chain beneath this bone if the chain remains intact, or status of the chain is not known. The drill should be moved from medial to lateral in this situation (*arrow*).



Fig. 6.110 The top of the ossicular chain is visualized (*arrow*).



Fig. 6.111 To avoid touching the ossicular chain with the drill, the burr is changed to a smaller one. Never push the burr medially. Movement should be either from medial to lateral, or parallel to the chain.

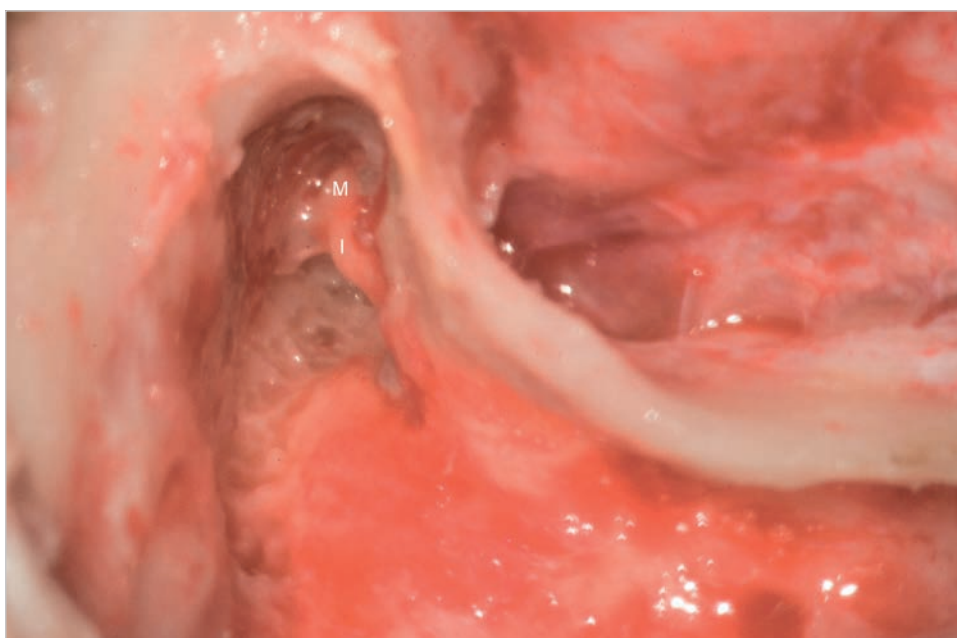


Fig. 6.112 The ossicular chain in the attic is visualized. No cholesteatoma is seen on the lateral face of it. I, incus; M, malleus.

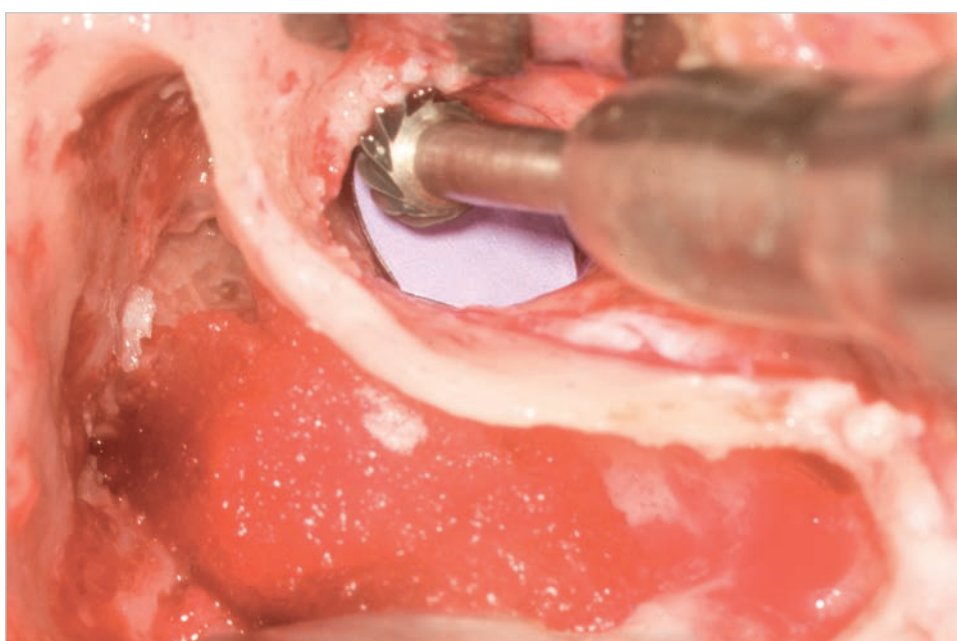


Fig. 6.113 After detaching the meatal skin medially, the bony meatus is calibrated to control the entire tympanic membrane. The tympanomeatal flap should be protected with an aluminum sheeting.

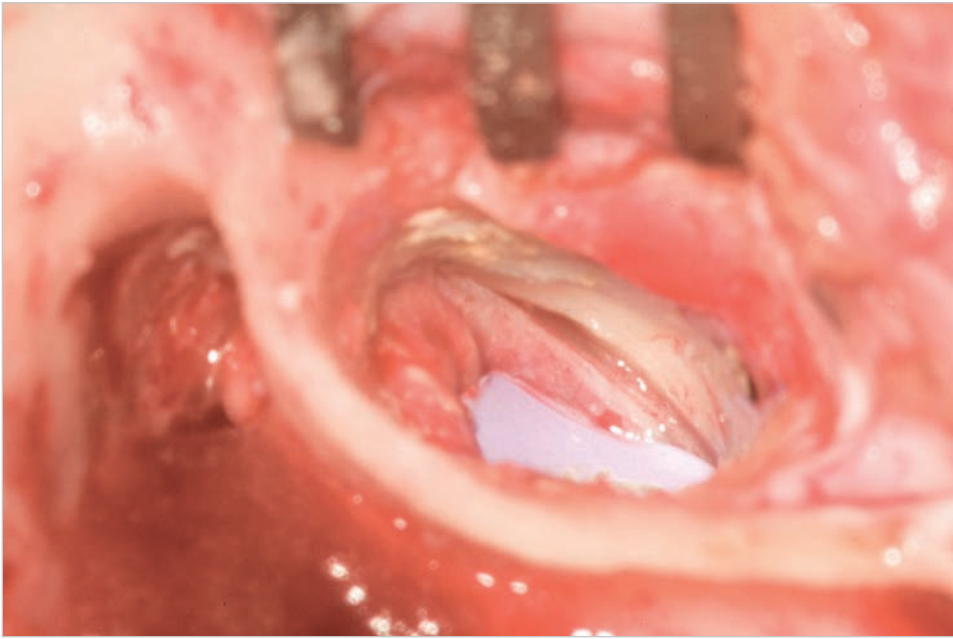


Fig. 6.114 An ideal canaloplasty facilitates not only cholesteatoma removal, but also postoperative care. The entire tympanic membrane can be controlled without moving microscope. The anterior part of the annular ligament is seen.

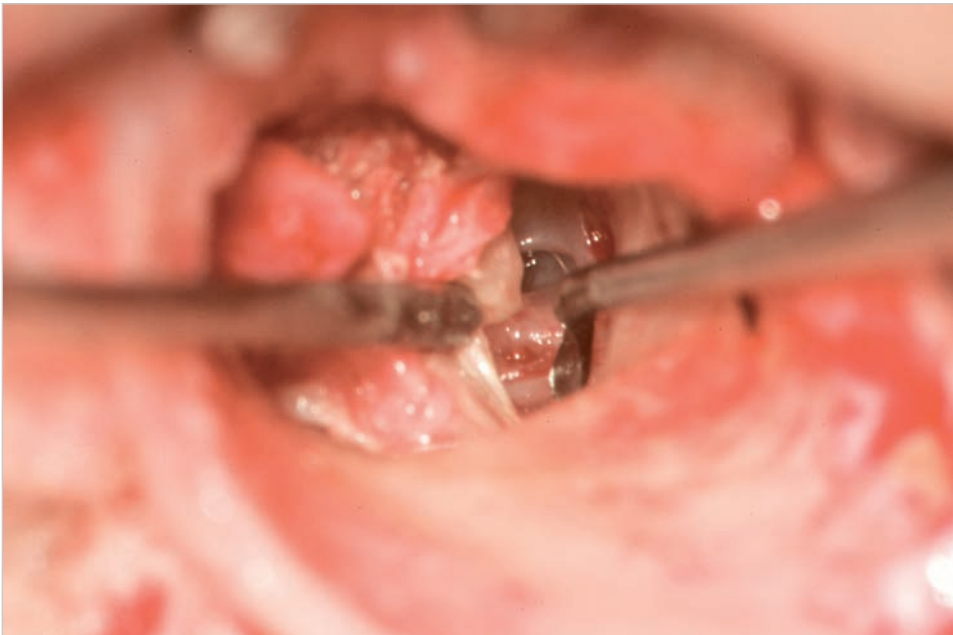


Fig. 6.115 The fibrous annulus is detached and the cavity is opened from inferior.



Fig. 6.116 The enlarged access to the cholesteatoma located in the posterosuperior part of the tympanic cavity, the posteroinferior wall of the external auditory canal is drilled. Care should be taken not to damage the facial nerve since the distal part of the mastoid segment of the nerve may course close to the posteroinferior wall.

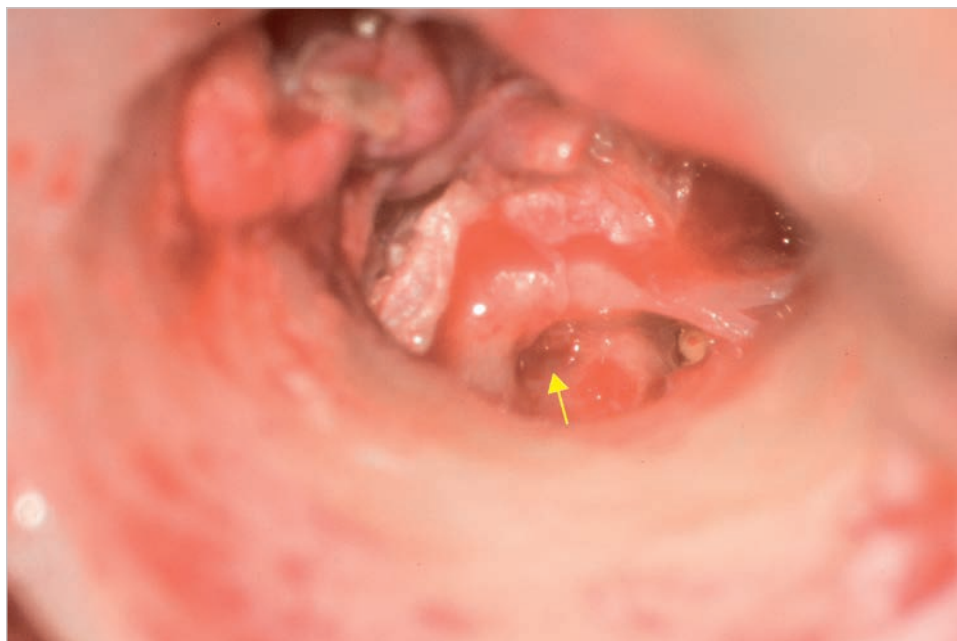


Fig. 6.117 The tympanic membrane adherent to the promontory is shown. The round window niche is free of disease. The round window membrane located at the anterosuperior aspect of the niche is seen (*arrow*).

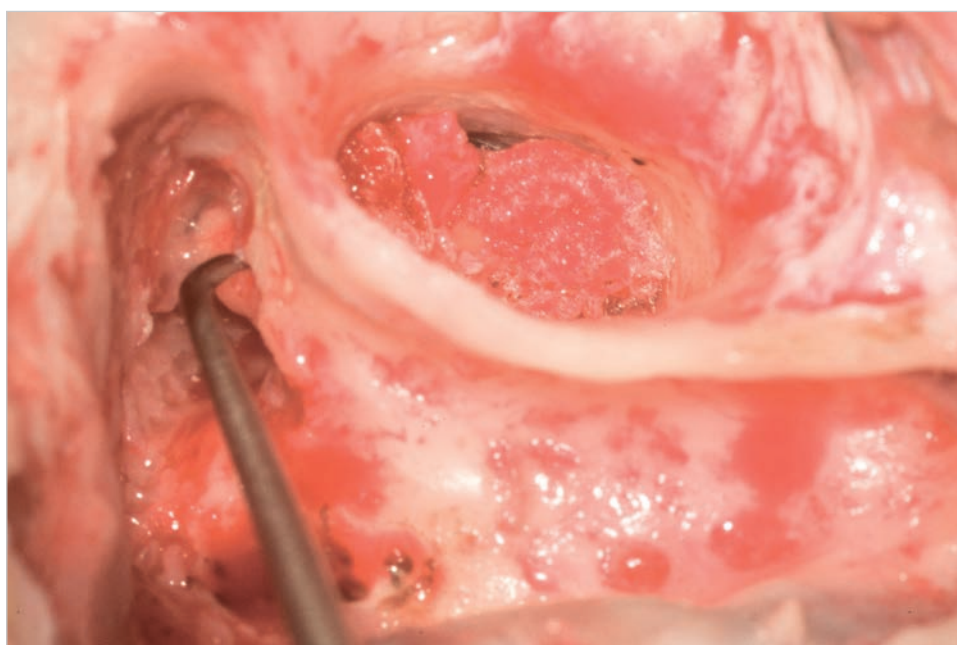


Fig. 6.118 After verifying erosion of the long process of the incus, the incudomalleolar joint is disarticulated from the mastoid using a dissector. The tympanic cavity is packed with cottonoid to achieve hemostasis.

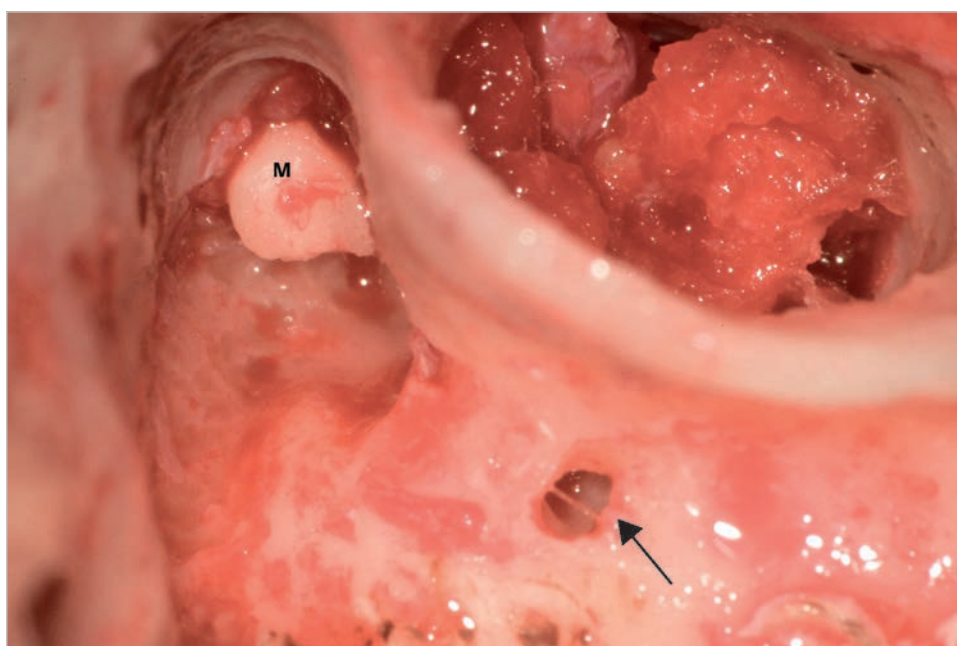


Fig. 6.119 The incus is removed and the bone just lateral to the lateral semicircular canal, inferior to the short process of the incus is drilled to carry out posterior tympanotomy. A small opening of the facial recess is seen (*arrow*). M, malleus.



Fig. 6.120 The posterior tympanotomy is ongoing. The matrix covering the facial recess is seen (*arrow*). M, malleus.

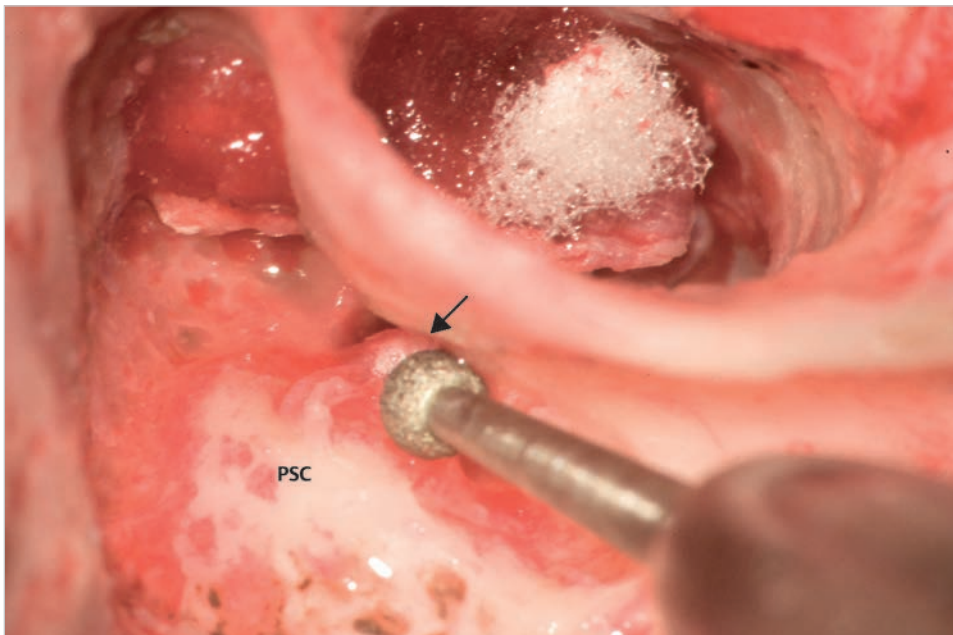


Fig. 6.121 The opening of the facial recess is enlarged inferiorly to perform posterior tympanotomy. The matrix covering the area of the stapes is started to be seen (*arrow*). PSC, posterior semicircular canal.

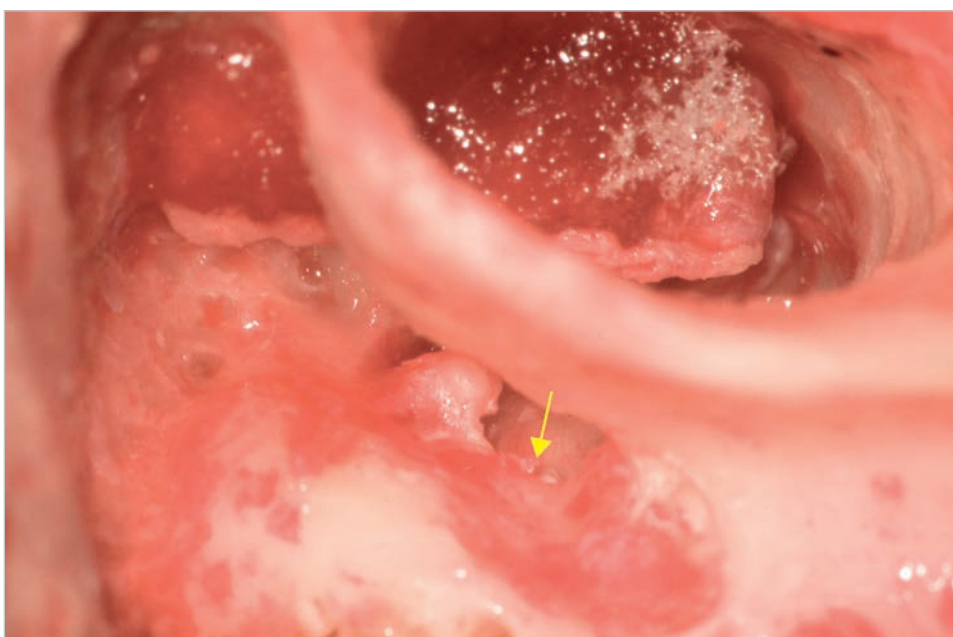


Fig. 6.122 The area of the stapes covered with matrix is visualized through posterior tympanotomy. To remove the matrix invaginating into the tympanic sinus (*arrow*), the pyramidal eminence should be removed.



Fig. 6.123 The pyramidal eminence impeding access to the tympanic sinus is removed with a small diamond burr. S, stapes.

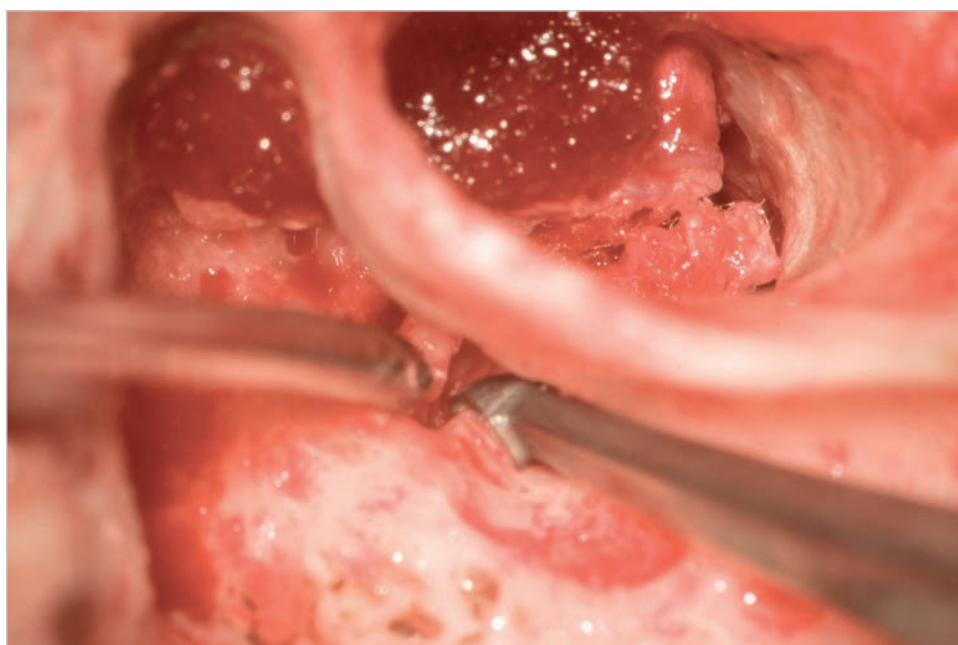


Fig. 6.124 The remaining bone can be removed with a curette after cutting the tendon of the stapedial muscle. Care should be taken in this maneuver not to damage the underlying facial nerve.



Fig. 6.125 Sharp dissection of the matrix from the superstructure with scissors is carried out through the posterior tympanotomy.

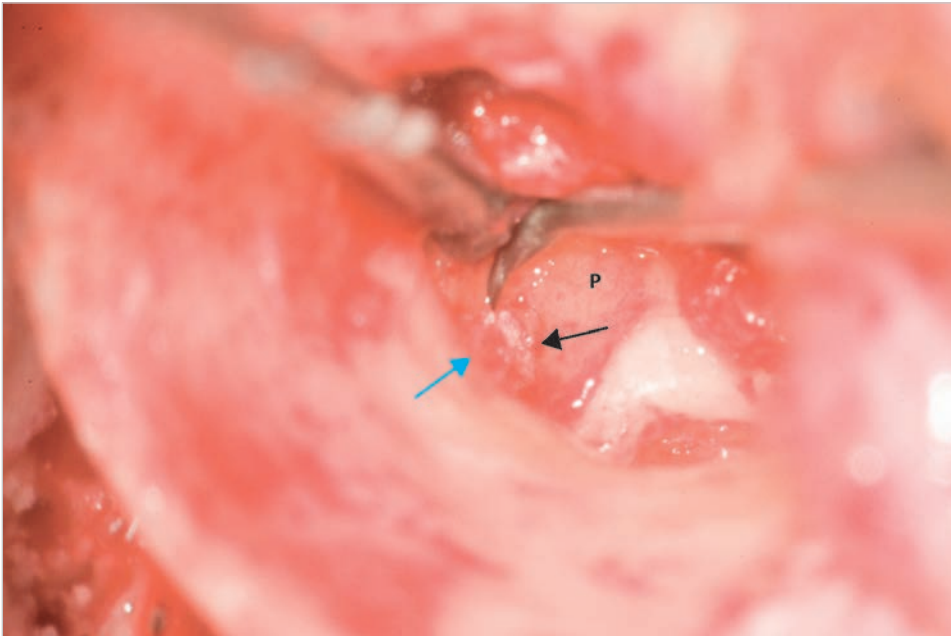


Fig. 6.126 The final piece of matrix (*black arrow*) located between the promontory and the stapes (*blue arrow*) is carefully dissected from the meatus. P, promontory.

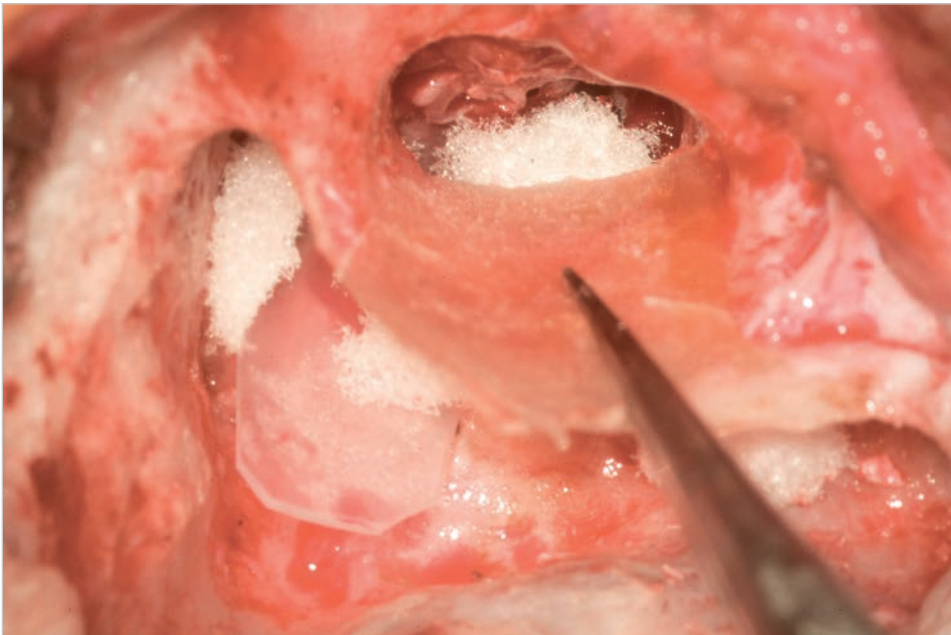


Fig. 6.127 The tympanic cavity is packed with pieces of Gelfoam, and a Silastic sheeting to cover both the tympanic cavity and the antrum is placed. Temporalis fascia is introduced into the meatus to reconstruct the tympanic membrane.

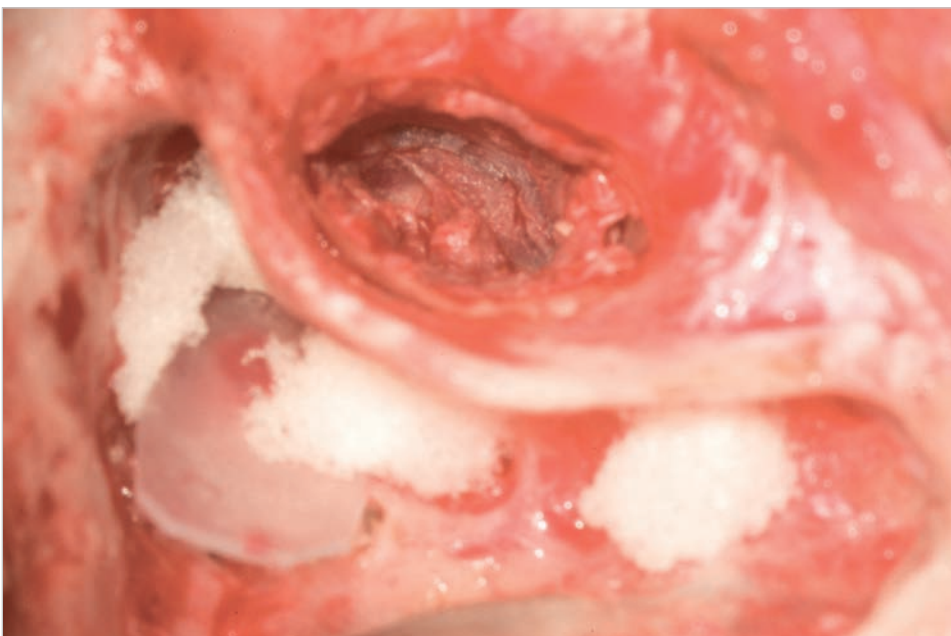


Fig. 6.128 The fascia is grafted underlay, and the tympanomeatal flap is replaced over it.

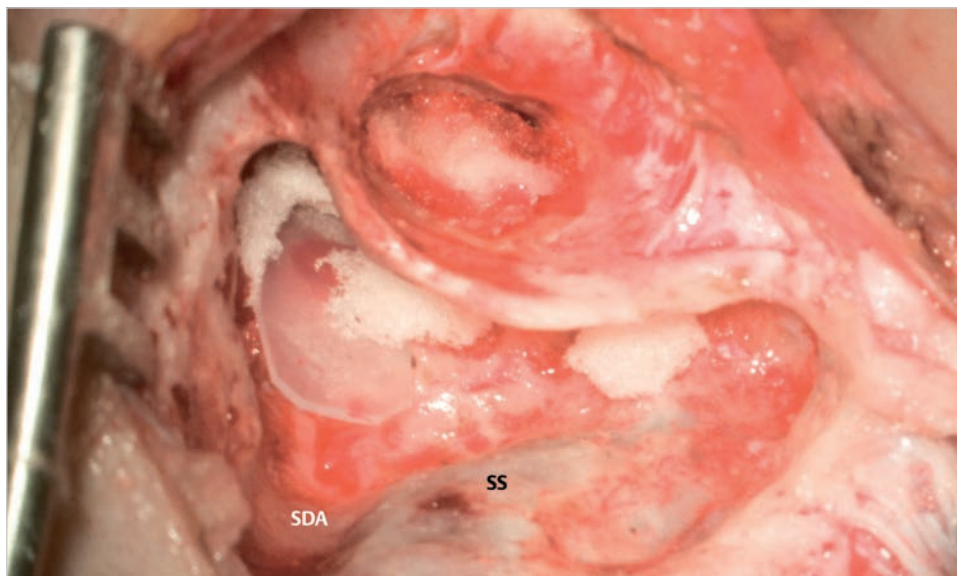


Fig. 6.129 The final shape of the cavity is shown. Note that the cavity is well-rounded, the sigmoid sinus is skeletonized, and the sinodural angle is opened sufficiently to obtain sufficient view from the mastoid that allows precise cholesteatoma removal. SDA, sinodural angle; SS, sigmoid sinus.

Case 6.5 (Left Ear)

See ▶ Fig. 6.130, ▶ Fig. 6.131, ▶ Fig. 6.132, ▶ Fig. 6.133, ▶ Fig. 6.134, ▶ Fig. 6.135, ▶ Fig. 6.136, ▶ Fig. 6.137, ▶ Fig. 6.138, ▶ Fig. 6.139, ▶ Fig. 6.140, ▶ Fig. 6.141, ▶ Fig. 6.142, ▶ Fig. 6.143.



Fig. 6.130 A case of epitympanic cholesteatoma in a child with pneumatized mastoid is shown. Bony protrusions limiting access to the tympanic membrane are seen in anterior and inferior walls.

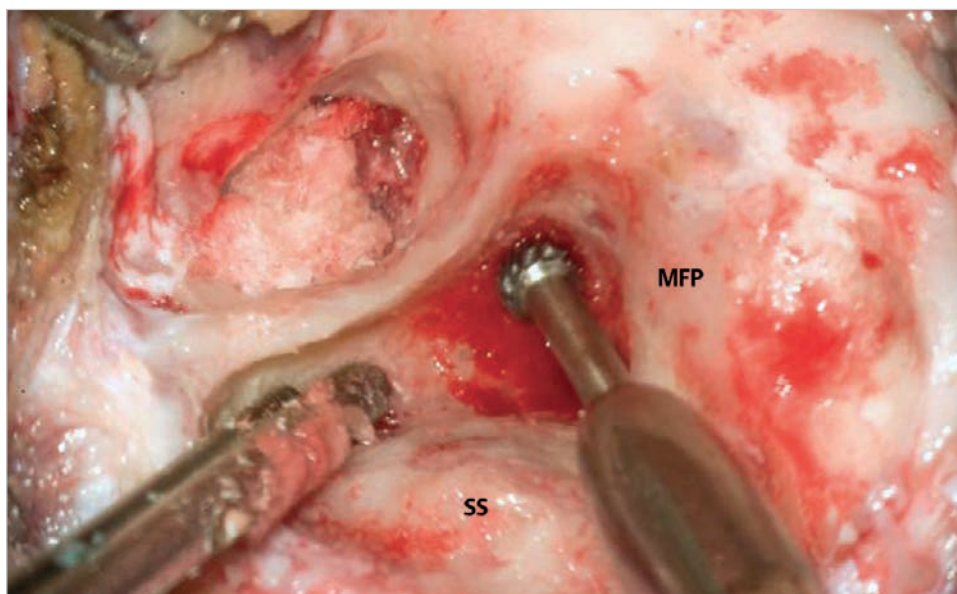


Fig. 6.131 Canal wall up tympanoplasty is carried out. The middle fossa plate and the sigmoid sinus is skeletonized. MFP, middle fossa plate; SS, sigmoid sinus.

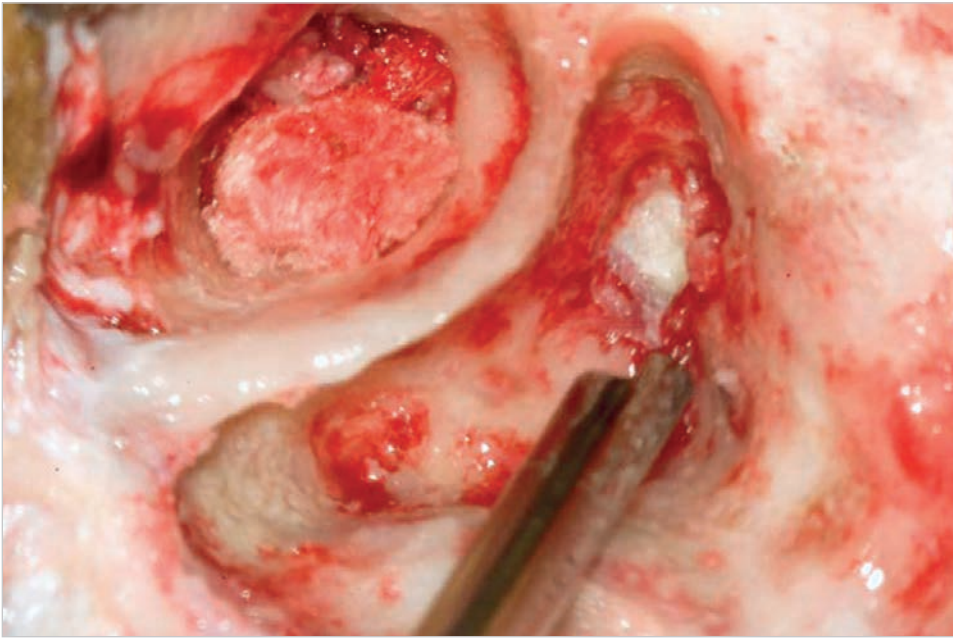


Fig. 6.132 Canal wall up tympanoplasty is carried out. The middle fossa plate and the sigmoid sinus is skeletonized. Opening of the antrum visualized the cholesteatoma filling the antrum.

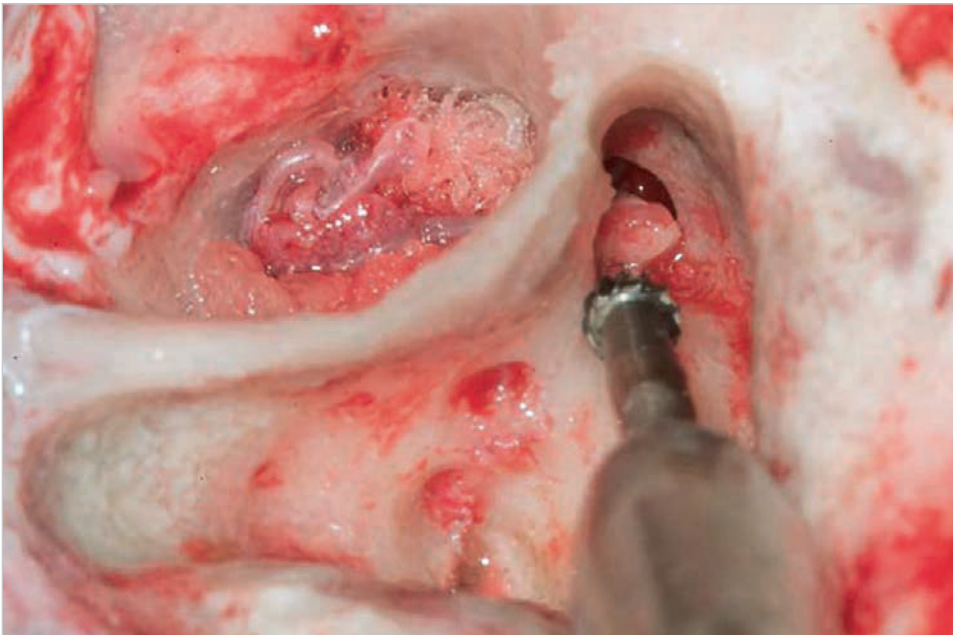


Fig. 6.133 Drilling has been advanced anteriorly to open the attic from the mastoid. Care should be taken not to make the canal wall too thin to avoid fenestration.

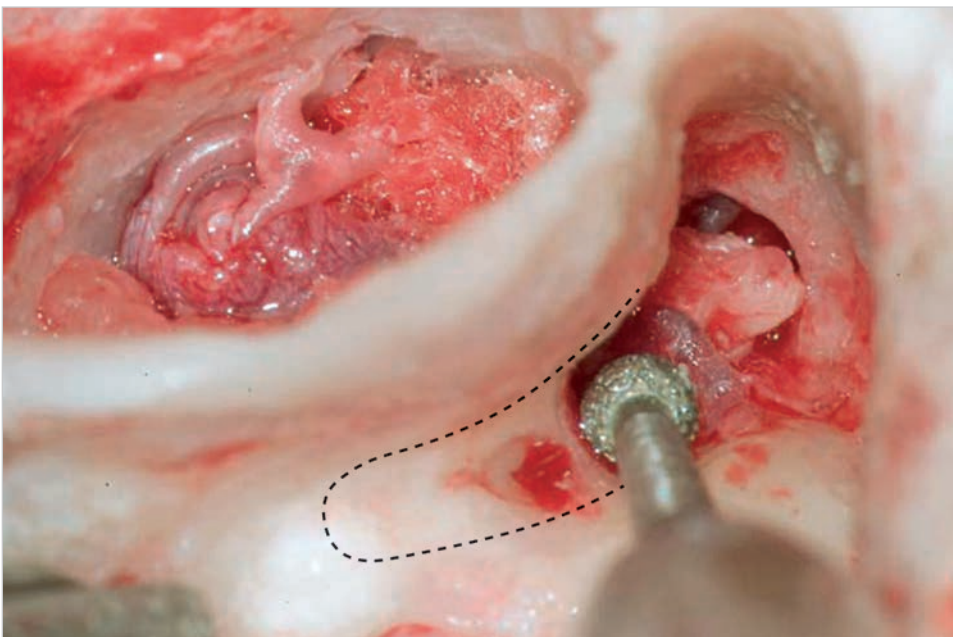


Fig. 6.134 With a diamond burr, the fossa incudis is extended inferiorly to perform posterior tympanotomy. Since the incus is already eroded in this case, the procedure does not insult the ossicular chain. The area to be drilled is indicated by the dotted line. The tympanotomy can be extended more inferiorly by sacrificing the chorda tympani nerve when there is a necessity to manage hypotympanum from the mastoid.



Fig. 6.135 Cholesteatoma filling the facial recess is shown.



Fig. 6.136 A combined approach is carried out to dissect cholesteatoma matrix from the area of the stapes. A suction is introduced into the area through the canal, the dissector through the posterior tympanotomy to obtain better view to the area. Meticulous care should be taken to remove pathology around the stapes.

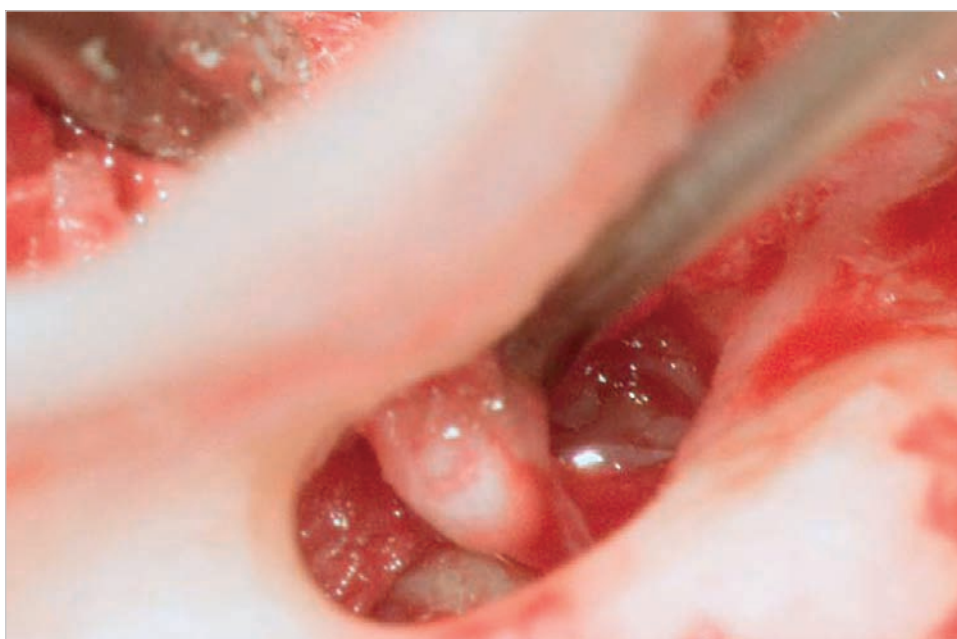


Fig. 6.137 The matrix is dissected from the superstructure of the stapes. The dissection should be carried out along the long axis of the footplate.

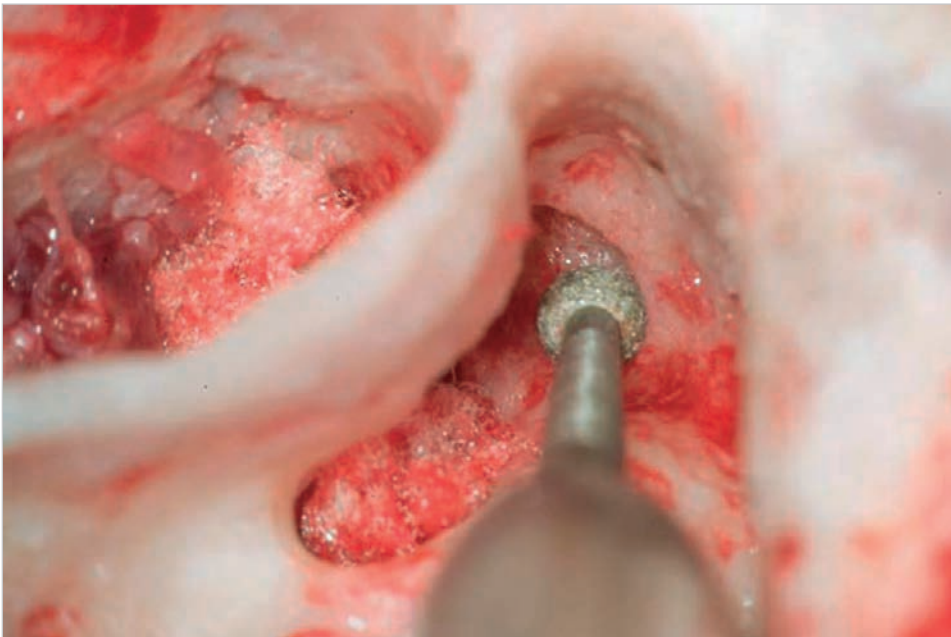


Fig. 6.138 The malleus has been removed to allow removal of cholesteatoma matrix from the supratubal recess. The cog separating the recess from the posterior attic is removed with a diamond burr.



Fig. 6.139 The cholesteatoma is eradicated from the middle ear. Note that the middle fossa plate and the sigmoid sinus are well skeletonized, and the sinodural angle is opened.



Fig. 6.140 A piece of Silastic sheeting is used to prevent postoperative adhesion of the tympanic membrane.

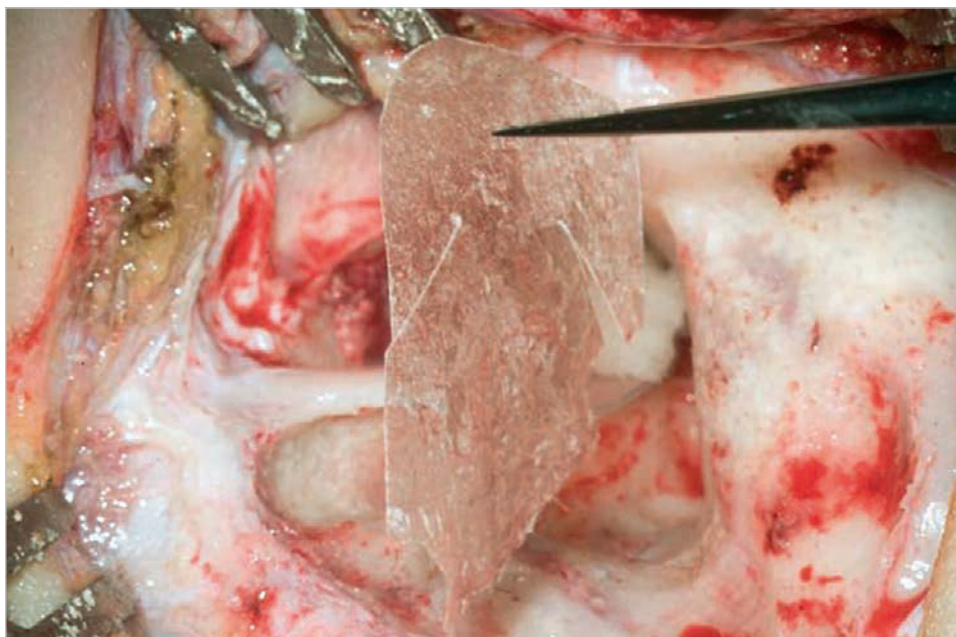


Fig. 6.141 After packing the tympanic cavity with Gelfoam, a piece of temporalis fascia is prepared to reconstruct the tympanic membrane. Two small cuts are made in the fascia. One tongue goes under the bony annulus inferiorly, and the other goes under the lateral wall of the attic to facilitate intimate attachment.



Fig. 6.142 The temporalis fascia is grafted underlay, and the tympanomeatal flap is replaced over the fascia.



Fig. 6.143 The erosion of the attic is closed with sandwich technique, with two pieces of cartilage and bone paste in between.

6.2 Second Stage and Revision Surgery after Canal Wall Up Technique

When treating cases of cholesteatoma, the second-stage operation should be planned to be carried out within 1 year after surgery in every case. The objectives are to remove possible residual cholesteatoma before a disease-like state and to reconstruct ossicular chain. If the cholesteatoma matrix is left intentionally in the area that is dangerous to dissect, second-stage surgery is usually planned to be carried out within 6 months.

The decision as to which approach is to be useful in a second-stage operation for cholesteatoma after closed tympanoplasty is based on where the disease was found in the first stage. The diagram we use regularly to show localization of the disease is shown in ► Fig. 6.144).

- If the cholesteatoma is located in the epitympanum, the antrum, or both, or the cholesteatoma matrix is intentionally left over the lateral semicircular canal at first-stage surgery, retroauricular–transmastoid approach is planned at the second stage to inspect the entire middle ear cavity (► Fig. 6.145).
- If the cholesteatoma is located only in the tympanic cavity including the posterior mesotympanum in the first stage, or the original lesion is not cholesteatoma, a transcanal approach is planned. In this case, second-stage surgery is carried out in the same manner as ossiculoplasty (► Fig. 6.146).

Even after canal wall reconstruction using bone paste and two layers of cartilage, cholesteatoma do recur in some cases. If there is recurrent cholesteatoma, atrophy of the posterior canal wall and/or cartilage used in the reconstruction, or any sign of retraction pocket, CWD technique is used in the second-stage or revision surgery both in adults and in children. (See also Chapter 7.1.4.)

6.2.1 Surgical Steps

1. After making retroauricular incision, the temporalis fascia or scar tissue formed after the previous operation is harvested. Before incising the subcutaneous flap, underlying bone is palpated to estimate whether any important structures, such as the sigmoid sinus or the middle fossa dura, are uncovered. The incision should be made over the bone to avoid injuring vital structures. Usually, a rectangular, anteriorly based flap is made by incising superiorly, posteriorly, and inferiorly to the cavity (► Fig. 6.147).
2. The subcutaneous flap is detached from the bone and, medially, from the mastoid cavity. The cavity is entered by incising the subcutaneous tissue and mucosa over the cavity wall. The tissue posterior to the auricle is held anteriorly with a self-retaining retractor. Do not disrupt the skin of the posterior canal wall at this time (► Fig. 6.148, ► Fig. 6.149).
3. In some cases, especially in children, the cavity is covered or almost closed by new bone formed after the previous surgery.
4. If access through the posterior cavity is not adequate for ossiculoplasty or for eradication of pathology, a combined approach is indicated. The meatal skin is detached from the bone. Care should be taken in this step, since the skin may be very thin in the second-stage operation. If canalplasty has already been carried out in the first stage, the meatal skin can be preserved intact. After the skin flap and the auricle are secured with a self-retaining retractor, newly formed bone over the edge of the mastoid is removed if it obscures

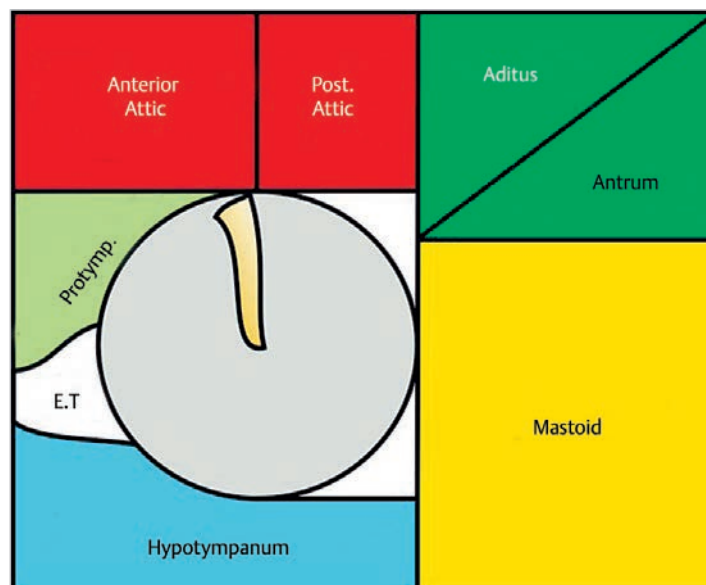


Fig. 6.144 Diagram to show location of cholesteatoma.

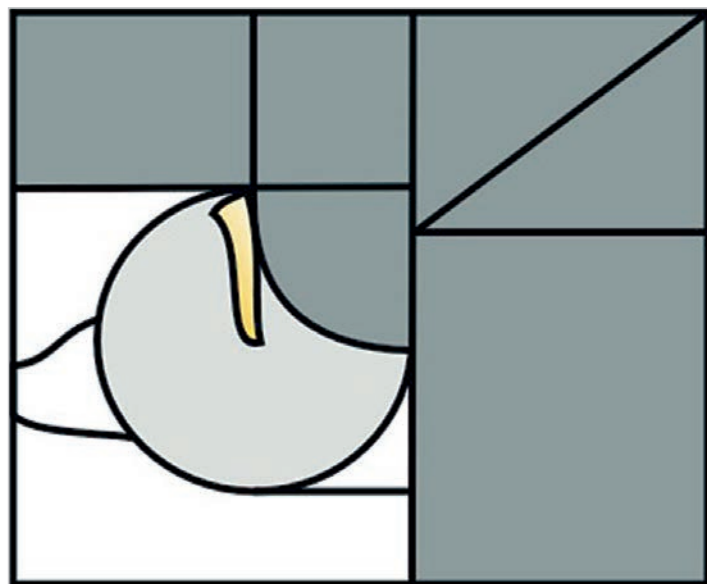


Fig. 6.145 The retroauricular–transmastoid approach.

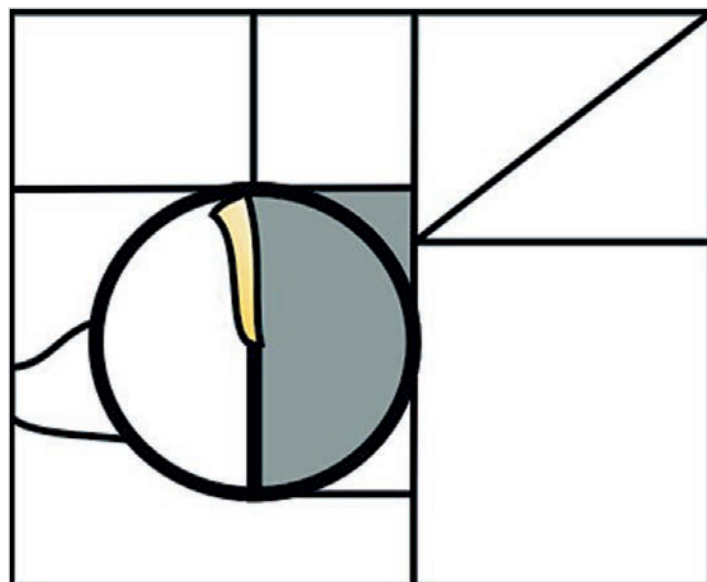


Fig. 6.146 The transcanal approach.

the view. The Silastic sheeting is removed from the posterior cavity (► Fig. 6.150, ► Fig. 6.151).

5. The posterior meatal skin is further detached to the level of the annulus. After cutting the middle ear mucosa and elevating the tympanomeatal flap, the tympanic cavity is entered. A small atticotomy is conducted if the stapes is not visible or it is necessary to visualize the attic. The reconstructed posterior wall may be partially removed for this purpose by resecting some of the cartilage. This cartilage can be replaced at the end of the procedure.
6. The middle ear is carefully inspected to check whether there is any residual disease. Residual cholesteatoma, if any, should be removed very carefully.
7. In some cases, the Silastic sheeting may be covered by a very thick mucosa, which may be hiding a small cholesteatoma behind it. To inspect the entire cavity, this mucosa should be removed completely.
8. If cholesteatoma is located at the level of the mastoid, aditus and perilabyrinthine cells, underlying mucosa, and bone must be drilled after removing the cholesteatoma. This reduces risk of residual epidermis in the cells.
9. If cholesteatoma is found at the posterior mesotympanum, the matrix should be removed from this area without disrupting it, and the mucosa carefully cleaned with further blunt dissection using cottonoids and the tympanic sinus hook.
10. At the same time, the tympanic cavity and the remaining ossicles are freed from any adhesive folds and scar tissue that could enclose the tympanic isthmus. The posterior meatal wall may be further reinforced with a piece of either autologous or homologous cartilage.
11. The ossicular chain is reconstructed, usually, with either autologous or homologous incus after molding. The tympanic cavity is filled with Gelfoam and the tympanomeatal flap is replaced. The external auditory canal is packed with Gelfoam.

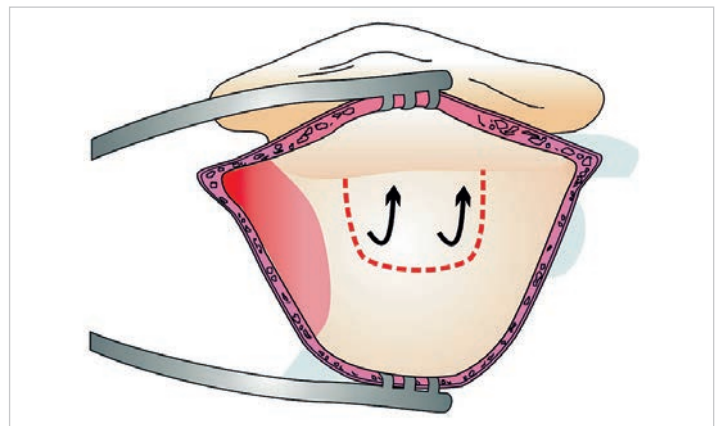


Fig. 6.147 A rectangular, anteriorly based flap is made.

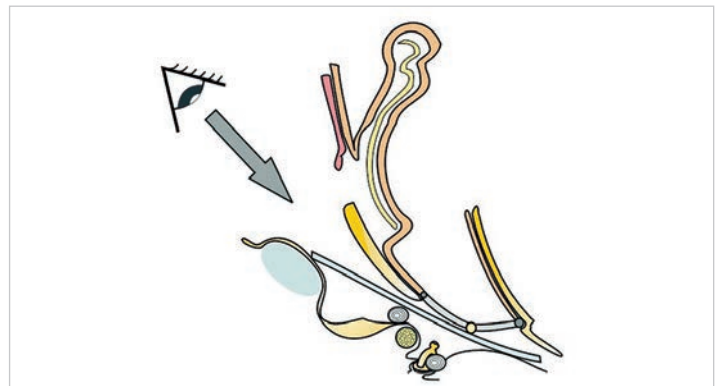


Fig. 6.148 The cavity is extended by incision tissues over the cavity wall.

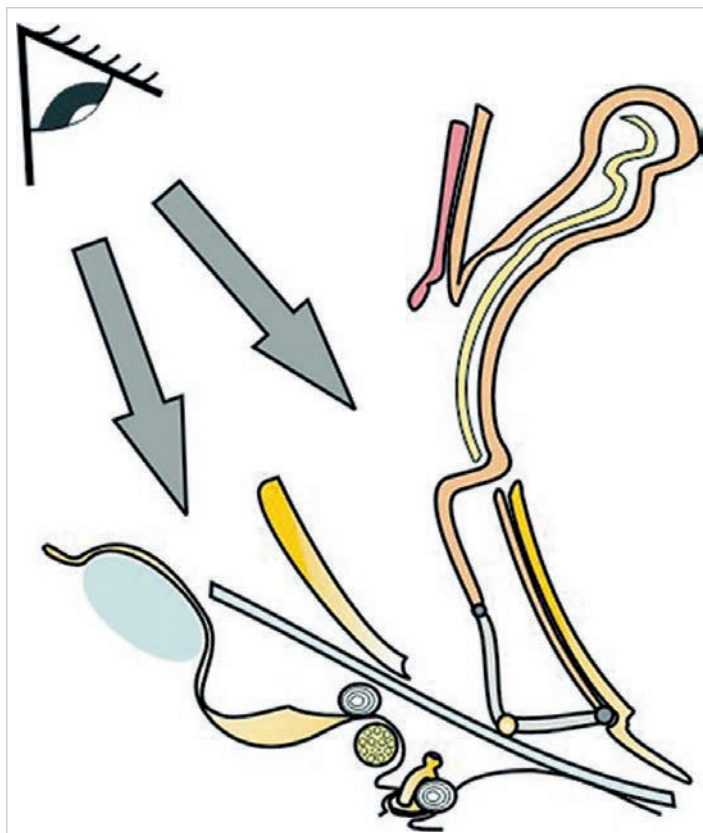


Fig. 6.150 A combined approach is indicated when access through the posterior cavity is not adequate.

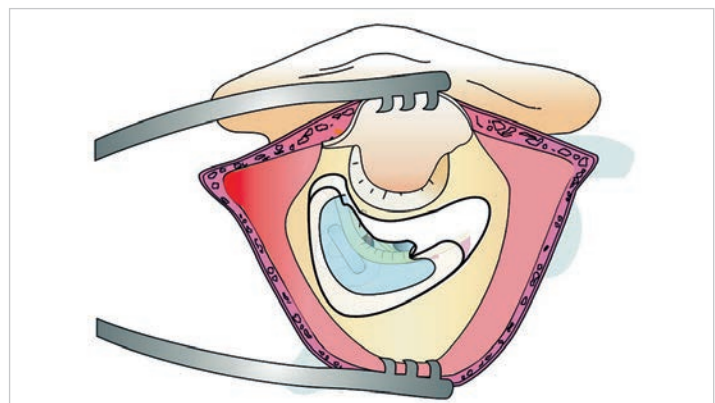


Fig. 6.149 Tissues posterior to the auricle are held by a retractor and meatal skin left intact at this moment.

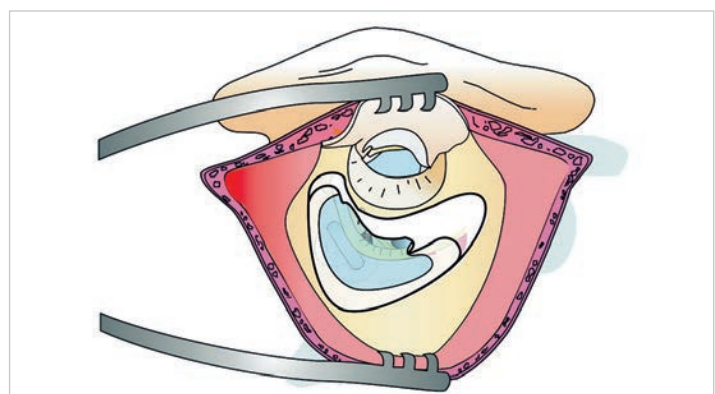


Fig. 6.151 Skin flap and auricle are held by the retractor, and newly formed bone is drilled.

Case 6.6 (Left Ear)

See ► Fig. 6.152, ► Fig. 6.153, ► Fig. 6.154, ► Fig. 6.155, ► Fig. 6.156, ► Fig. 6.157, ► Fig. 6.158.



Fig. 6.152 Second-stage surgery after canal wall up tympanoplasty removing mesotympanic cholesteatoma. Since the cholesteatoma was limited to the tympanic cavity in the first stage, the surgery can be performed under an ear speculum. Opening of the tympanic cavity via U-shaped incision in the meatus revealed a residual cholesteatoma forming a small pearl on the head of the stapes. The Silastic sheeting placed in the first-stage surgery is seen inferiorly.

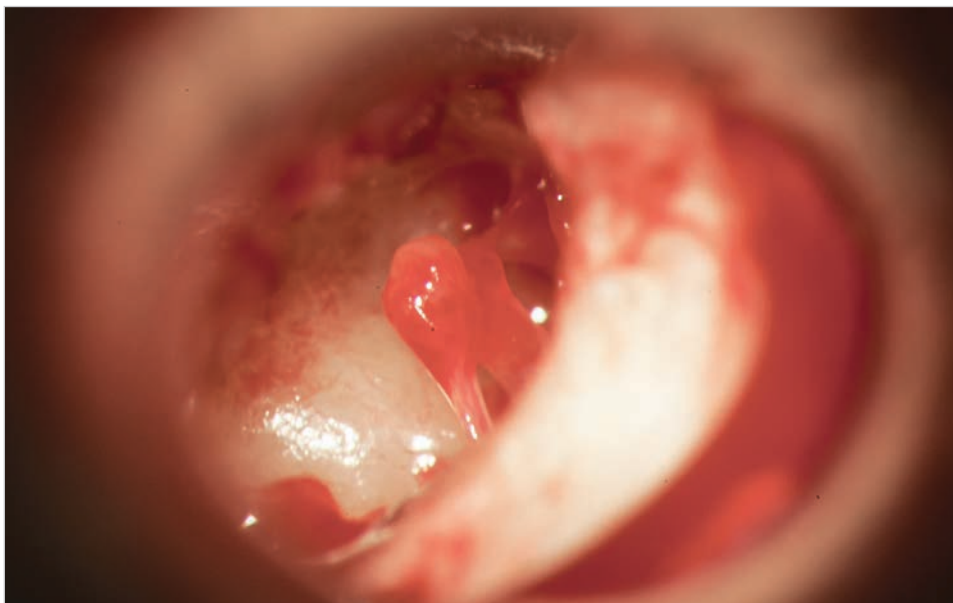


Fig. 6.153 The Silastic sheeting is taken out, and the pearl is removed without difficulty.

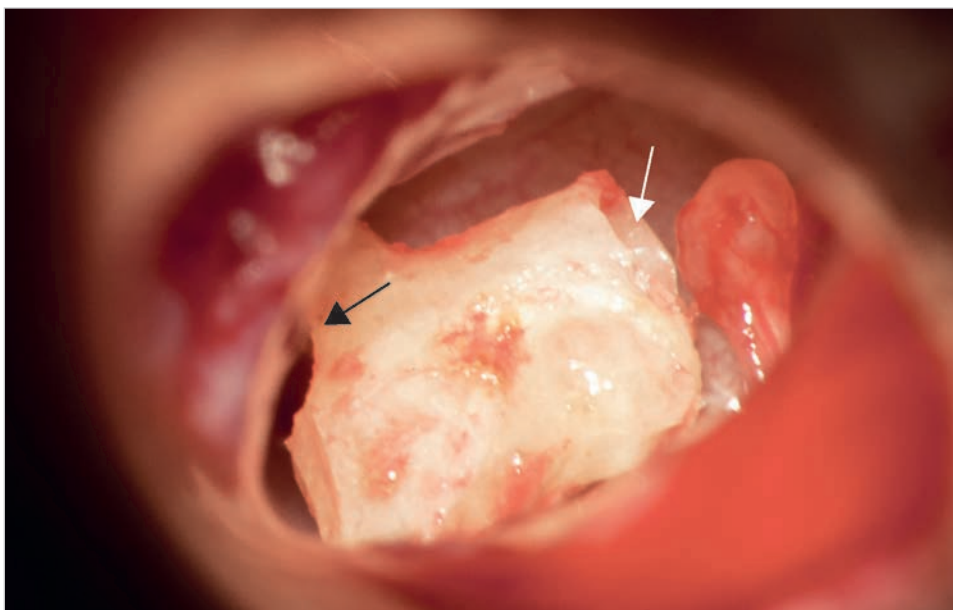


Fig. 6.154 The incus taken in the first stage and preserved is used as a columella. The columella has a hole (*white arrow*) for the head of the stapes and a groove (*black arrow*) for the handle of the malleus. The columella is placed beside the stapes.

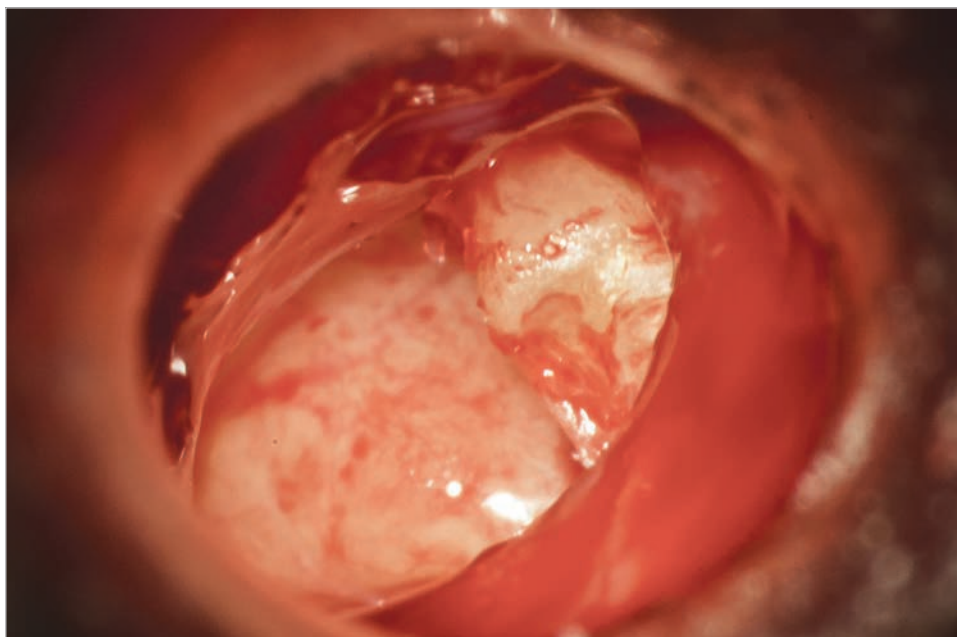


Fig. 6.155 The columella is interposed between the stapes and the handle of the malleus.

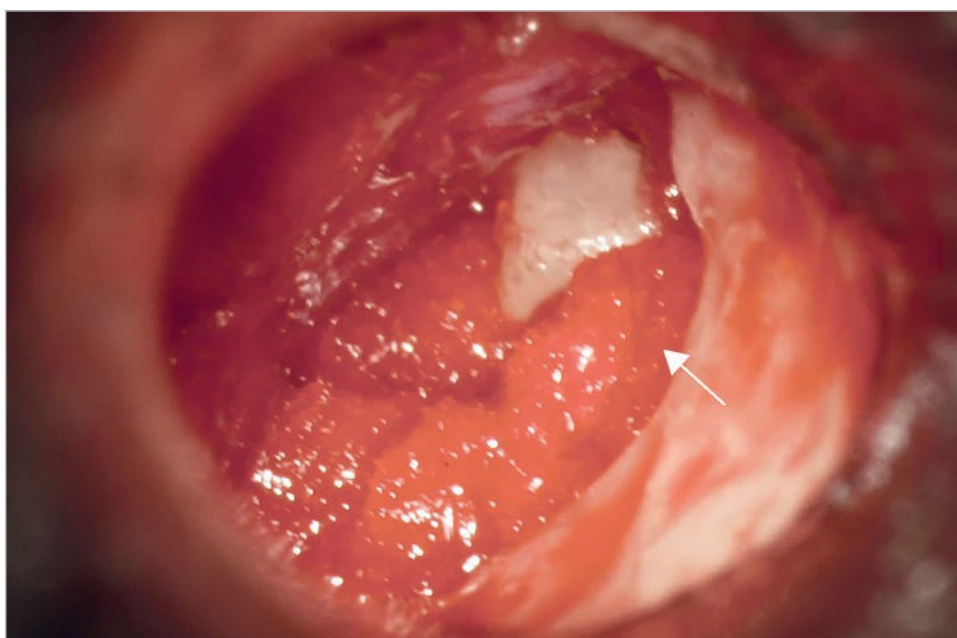


Fig. 6.156 The tympanic cavity is packed with Gelfoam. A small piece of Gelfoam should be placed posteriorly to the columella (*arrow*) to prevent postoperative adhesion to the posterior wall.

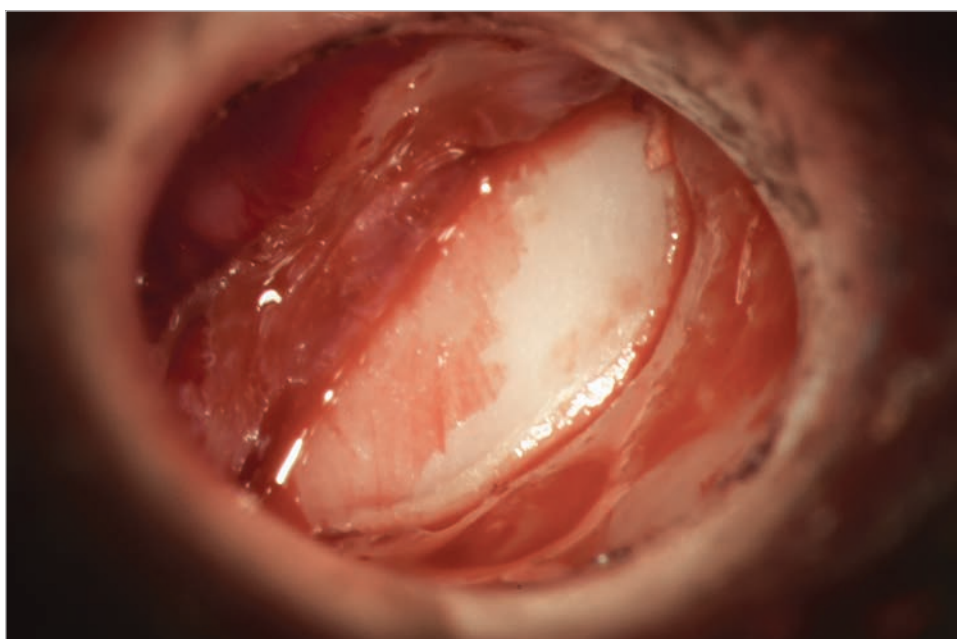


Fig. 6.157 A piece of cartilage is placed over the columella to reinforce the posterosuperior quadrant of the tympanic membrane.

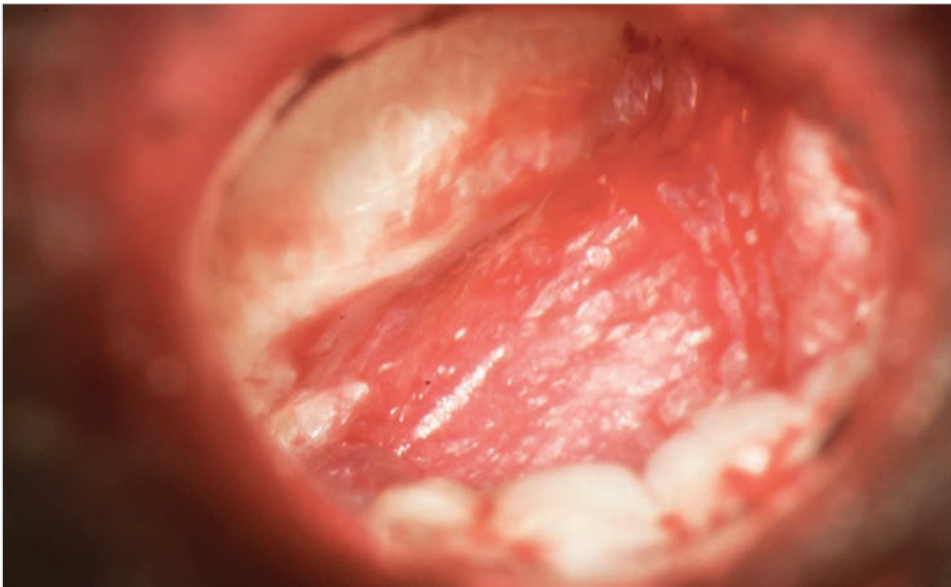


Fig. 6.158 The tympanic membrane is replaced to close the tympanic cavity. The external auditory canal is packed with Gelfoam.

Case 6.7 (Right Ear)

See ► Fig. 6.159, ► Fig. 6.160, ► Fig. 6.161, ► Fig. 6.162, ► Fig. 6.163, ► Fig. 6.164, ► Fig. 6.165, ► Fig. 6.166, ► Fig. 6.167, ► Fig. 6.168, ► Fig. 6.169, ► Fig. 6.170, ► Fig. 6.171.

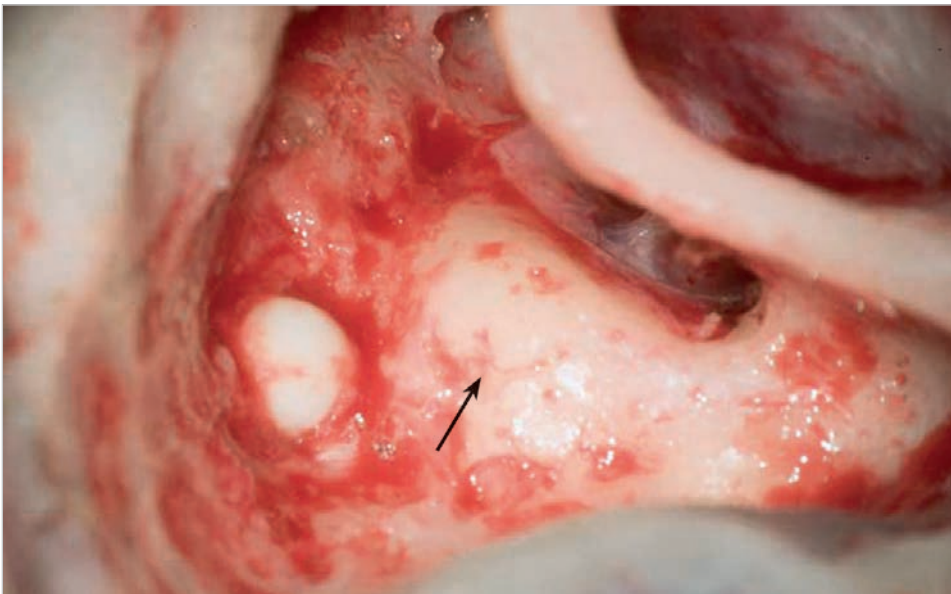


Fig. 6.159 Second-stage operation after canal wall up tympanoplasty. Since cholesteatoma is advanced into the mastoid, retroauricular incision is indicated. A Silastic sheeting placed in the first stage is already removed. The tympanic cavity covered with healthy mucosa is seen through a posterior tympanotomy performed in the first stage. Residual cholesteatoma is seen over the perilyabyrinthine cells superior to the lateral semicircular canal (arrow).



Fig. 6.160 The cholesteatoma is removed from the antrum. The cholesteatoma forms a pearl, and en block removal is achieved.

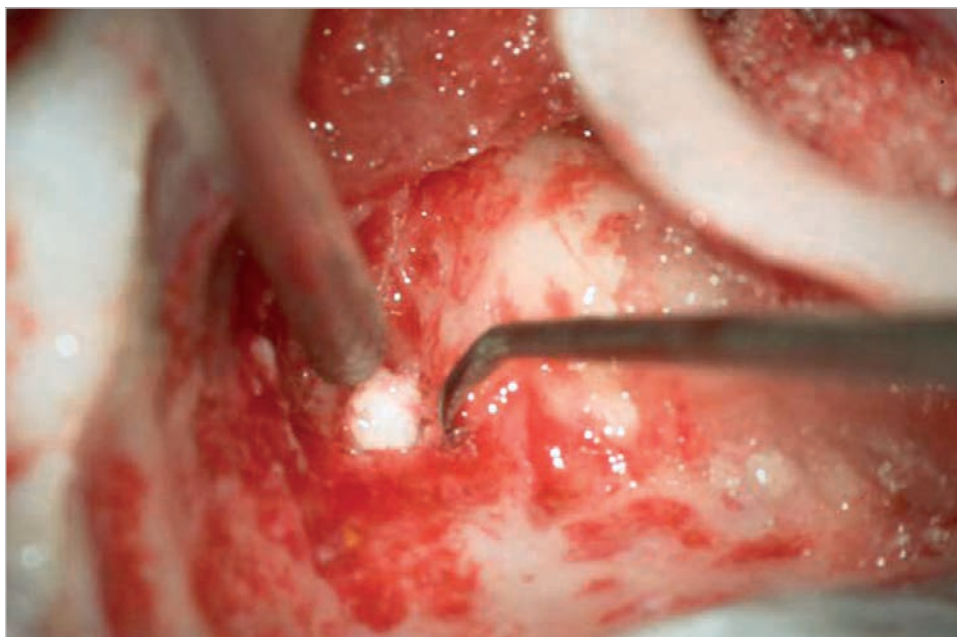


Fig. 6.161 Under the cholesteatoma shown above, the other cholesteatoma invaginating into the perilabyrinthine cell is present.

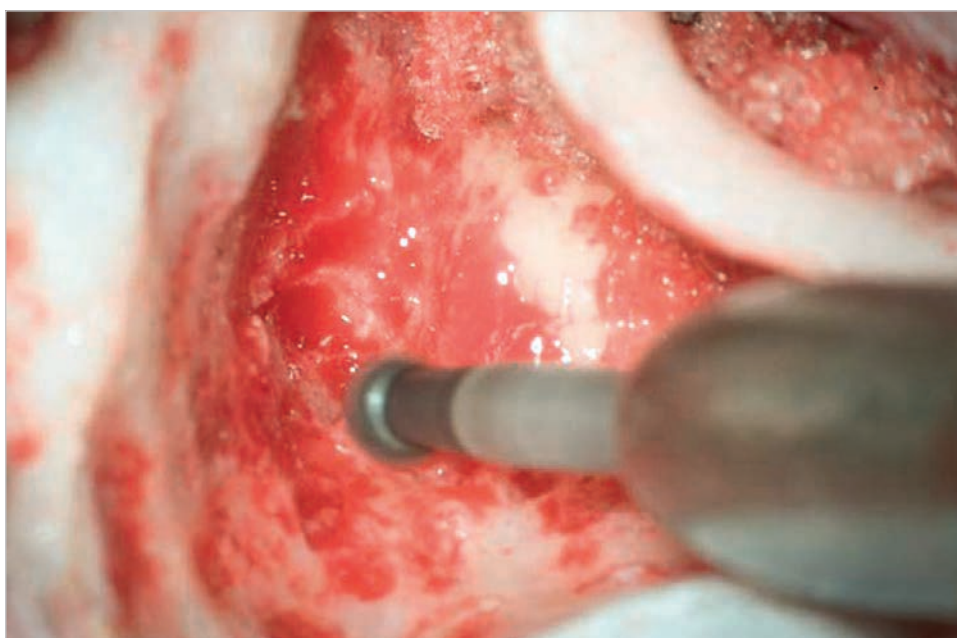


Fig. 6.162 The medial end of the matrix invaginates perilabyrinthine cells. The cells holding cholesteatoma matrix are drilled with a cutting burr. The area corresponds to the center of the superior semicircular canal where the subarcuate artery go through. The distance from the medial wall of the antrum to the posterior end of the superior semicircular canal is large enough for safe removal of the cells bone from this area.

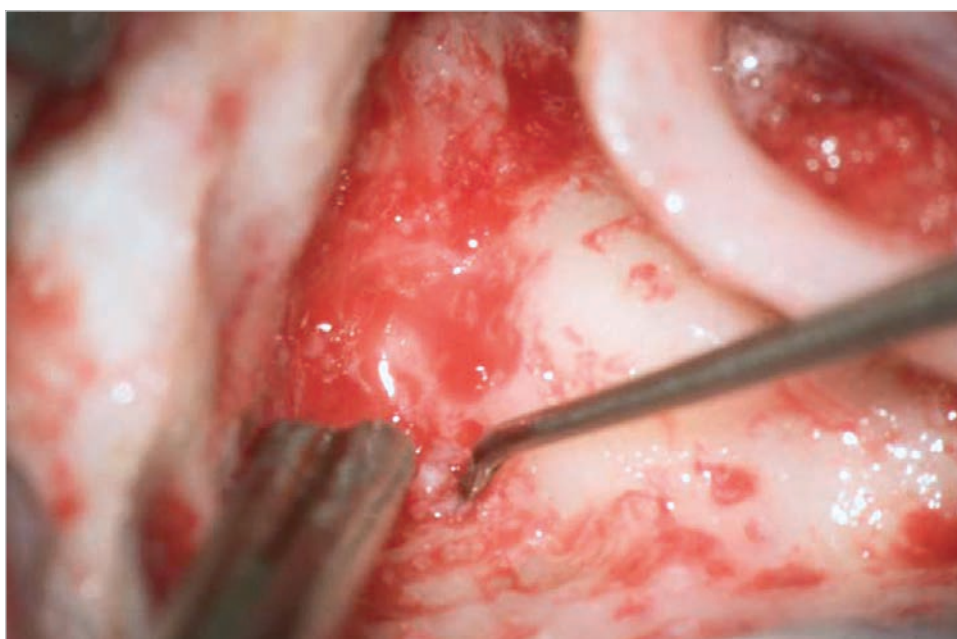


Fig. 6.163 The matrix infiltrating into small air cell tracts are exposed. If diamond burrs are used in such situation, the matrix can be overlooked.

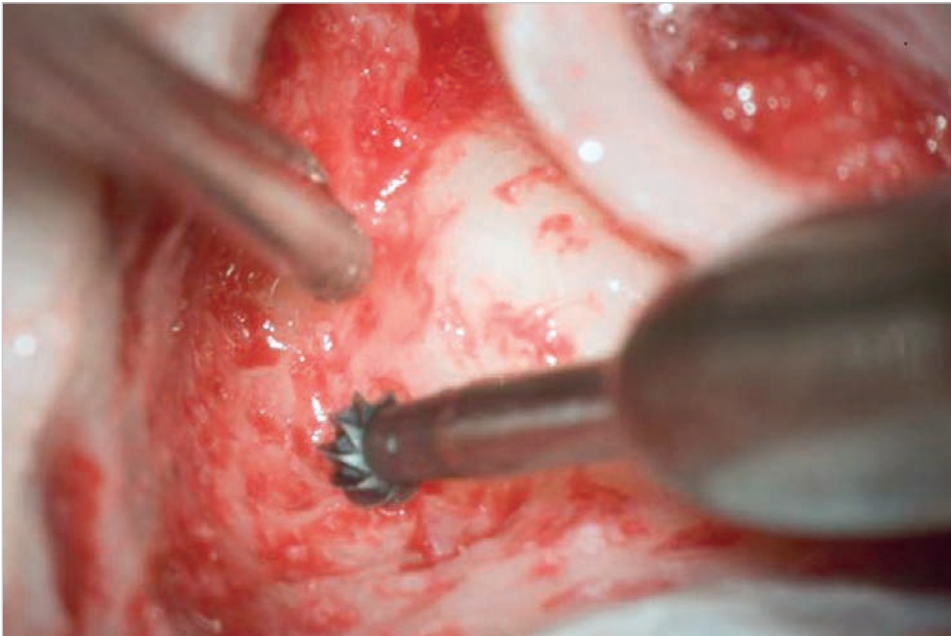


Fig. 6.164 The perilabyrinthine cells are further removed with a cutting burr.

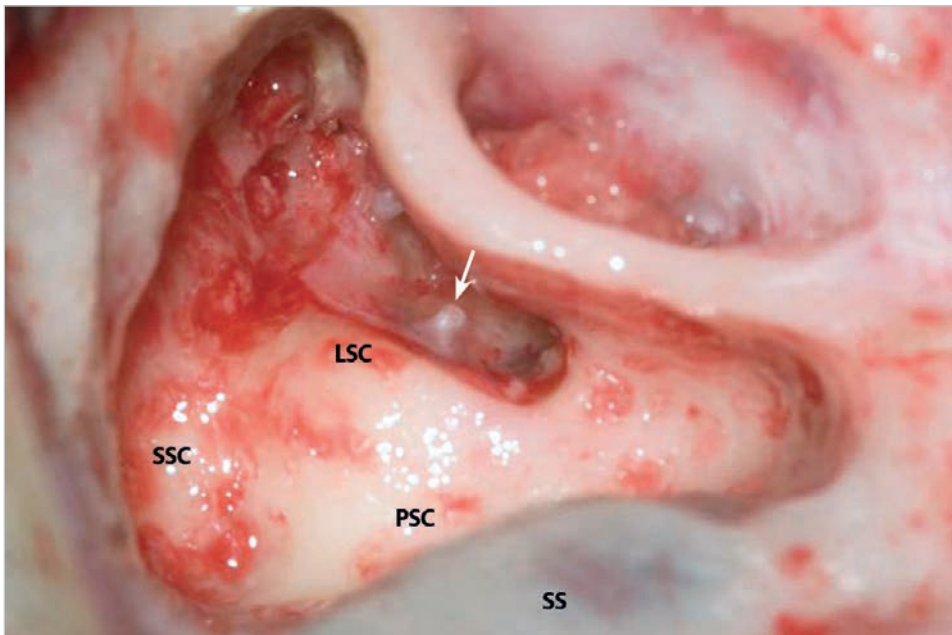


Fig. 6.165 The cells accommodating the matrix are eliminated. Contours of the otic capsule containing semicircular canals are seen. Through the posterior tympanotomy, head of the stapes is visible (*arrow*). LSC, lateral semicircular canal; PSS, posterior semicircular canal; SS, sigmoid sinus; SSC, superior semicircular canal.

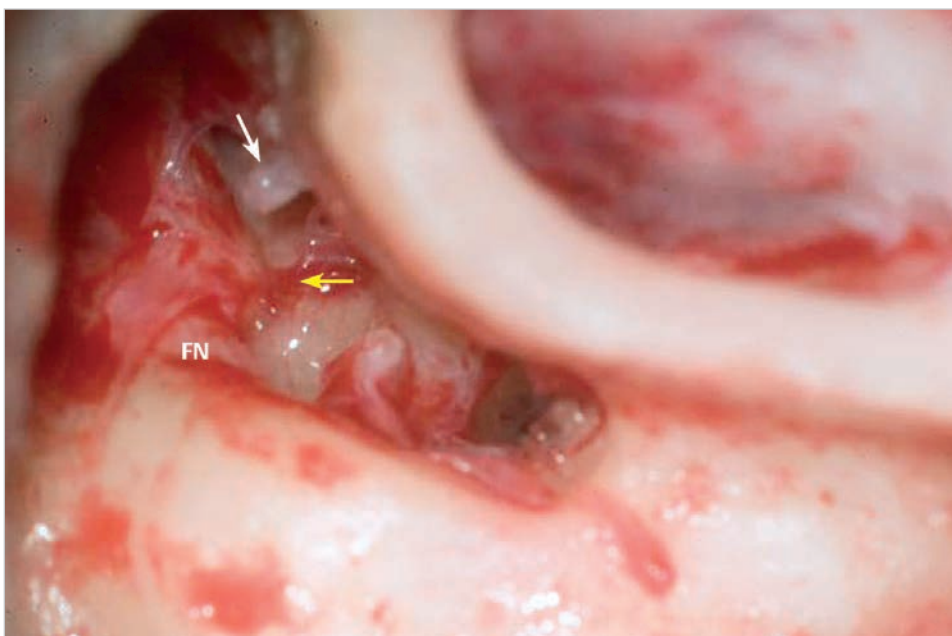


Fig. 6.166 Mucosal coverage over the area of the stapes is removed. The anterior crus of the stapes is missing due to bone erosion. The incus and the head of the malleus were removed in the first-stage surgery, but the manubrium of the malleus is in place. The remnant of the tendon of the tensor tympani muscle attaching to the malleus (*white arrow*) and the cochleariform process (*yellow arrow*) are seen. The facial nerve coursed just superior to the cochleariform process. FN, facial nerve.



Fig. 6.167 Since the anterior crus is missing and the posterior crus is eroded to some extent, ossiculoplasty between the footplate and the malleus is indicated. The articular face of the incus is removed to avoid contact with the posterior canal wall. The tip of the incus is drilled to make incus more stable over the footplate. The inferior face of the body is drilled to avoid contact with the promontory. A notch to accommodate the manubrium of the malleus is created on the superior face of the body.



Fig. 6.168 Before reconstruction, the tympanic cavity is loosely packed with pieces of Gelfoam. The Gelfoam serves as a barrier to avoid the columella falling down deeply into the tympanic cavity during the placement procedure, and as a support to hold the columella in place postoperatively.

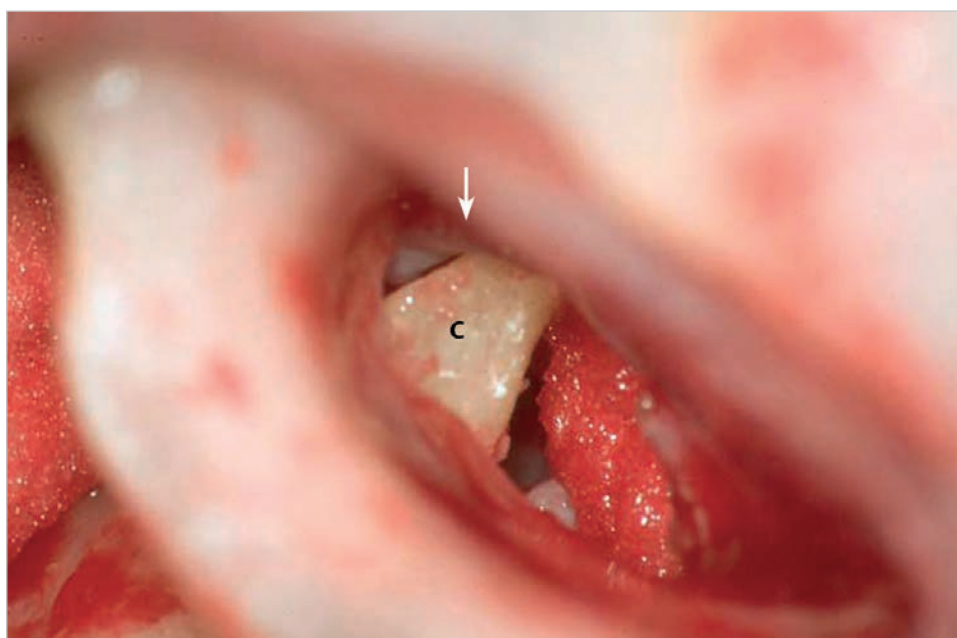


Fig. 6.169 The columella is arranged between the footplate and the handle of the malleus. Note that the notch created in the superior face of the incus accommodates the manubrium of the malleus (arrow). C, columella.

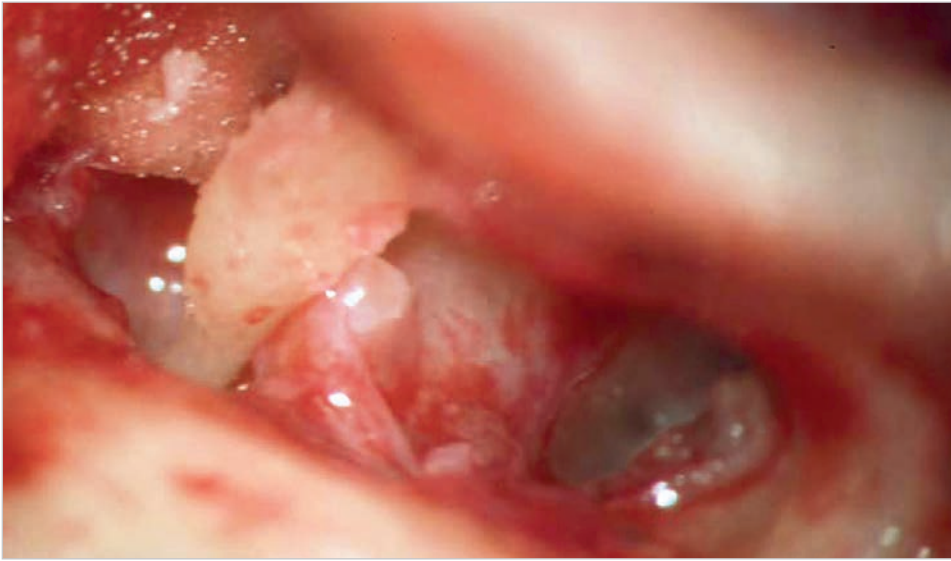


Fig. 6.170 The arrangement of the columella is checked through the posterior tympanotomy. To stabilize the columella more, it is leaned against the remaining superstructure.



Fig. 6.171 Small pieces of Gelfoam is placed around the columella for additional stabilization. It is important to put a small piece of Gelfoam between the posterior wall and the columella (*arrow*) to avoid postoperative fixation.

Case 6.8 (Right Ear)

See ► Fig. 6.172, ► Fig. 6.173, ► Fig. 6.174, ► Fig. 6.175, ► Fig. 6.176, ► Fig. 6.177, ► Fig. 6.178, ► Fig. 6.179, ► Fig. 6.180, ► Fig. 6.181.



Fig. 6.172 The patient has been operated three times in other department, resulting in lateralization of the tympanic membrane with conductive hearing loss. Revision tympanoplasty is conducted through retroauricular approach. An anteriorly based soft tissue flap is harvested.



Fig. 6.173 The space under the lateralized tympanic membrane is opened. Debris suggesting presence of residual skin in the middle ear is seen.



Fig. 6.174 By pushing the meatal skin anteriorly, the original tympanic membrane remained in place is visualized. Residual skin producing debris is identified on the medial face of it.

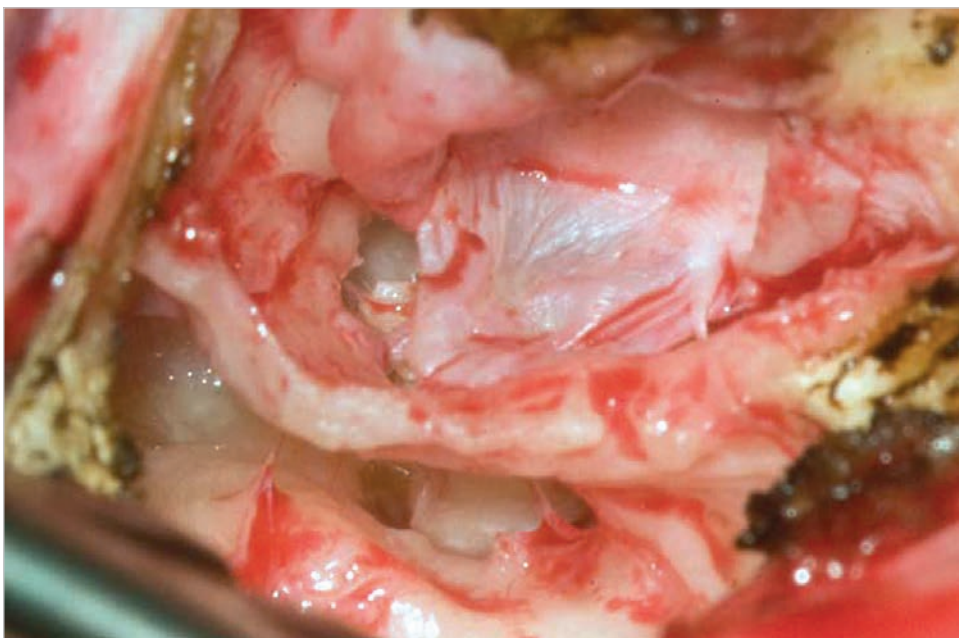


Fig. 6.175 The lateralized tympanic membrane is placed back to show.

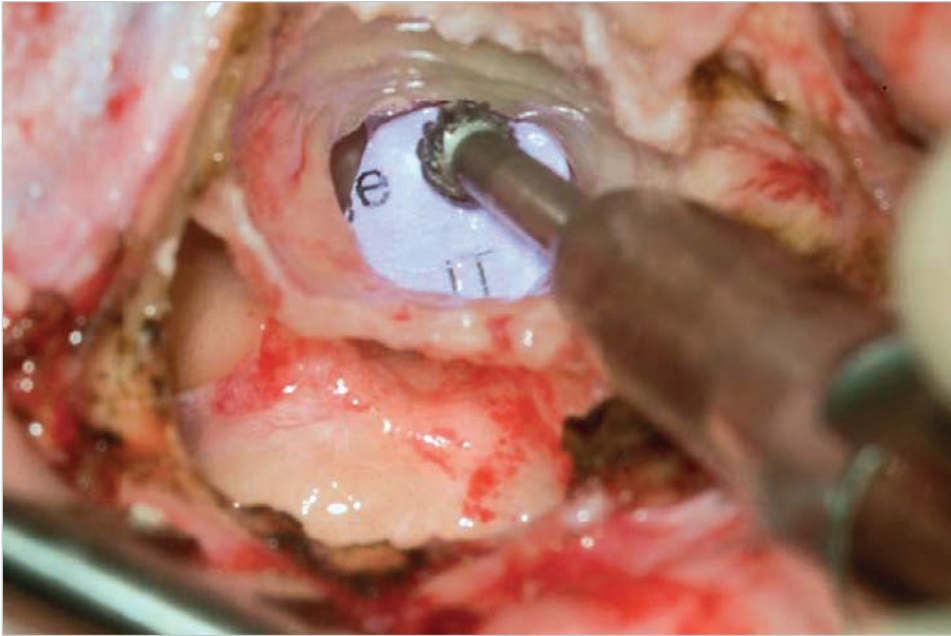


Fig. 6.176 Canaloplasty is conducted to obtain adequate exposure, and to remove mucosa covering the bony wall located medially to the lateralized tympanic membrane. The residual tympanic membrane is protected by aluminum sheeting.

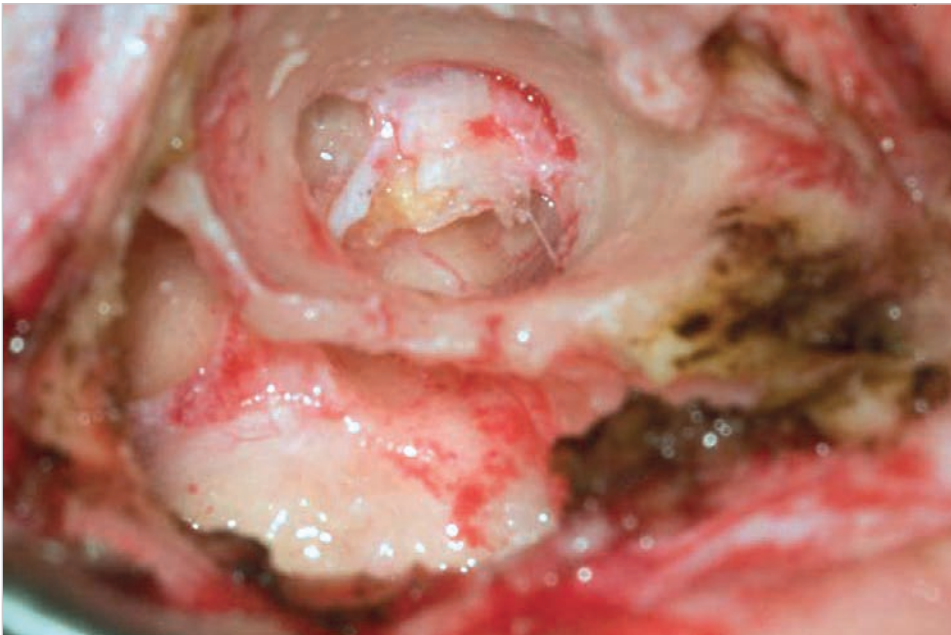


Fig. 6.177 The TORP placed in the former surgery covered with debris is seen.



Fig. 6.178 The TORP is taken out, and the residual skin is removed with the remnant of the original tympanic membrane.



Fig. 6.179 The tympanic cavity is partially packed with Gelfoam. The footplate can clearly be seen.



Fig. 6.180 After packing the tympanic cavity with Gelfoam, a piece of temporalis fascia is grafted under the remnant of original tympanic membrane.

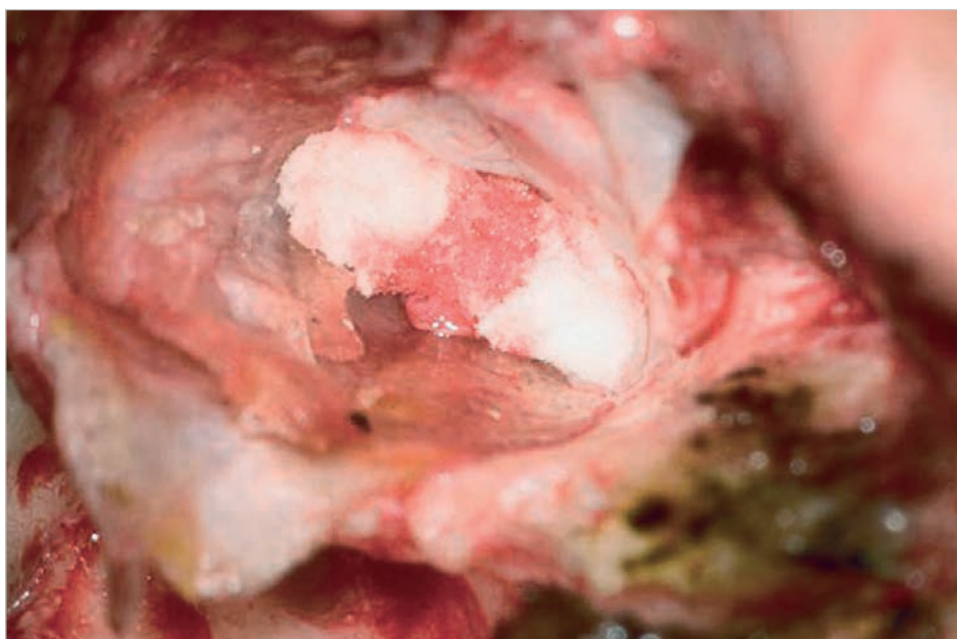


Fig. 6.181 The meatal skin with the lateralized tympanic membrane is replaced over the fascia, and the canal is packed with Gelfoam.

6.3 Hints and Pitfalls

- Management of middle ear cholesteatoma has to be individualized to the patients and the type of disease.
- There are many procedures in closed tympanoplasty, and each has its indications, advantages, and disadvantages.
- The surgeon must be prepared to perform all the procedures that might be required.
- The pneumatization of the mastoid, the size of the epitympanic erosion, and both ipsi- and contralateral residual hearing should be taken into consideration to decide between an open and a closed techniques.
- Canalplasty should be completed before mastoidectomy. In that way, we can define the anterior limit of mastoidectomy with taking thickness of the posterior wall into account.
- Evacuation of cholesteatoma debris is very effective to visualize the underlying structures.
- Removal of cholesteatoma matrix from the posterior mesotympanum should be performed using the combined approach.
- Presence of labyrinthine fistula should always be suspected. For that reason, debris covering the lateral semicircular canal is removed but the matrix over the lateral semicircular canal must be left in place initially. The matrix can be detached after verifying absence of labyrinthine fistula.
- If a fistula is seen under the matrix, it should be managed appropriately at the end of surgery (see Chapter 10.1).
- Preoperative radiological examinations are usually not indispensable. Computed tomography is indispensable in cases with vertiginous symptoms, history of facial nerve palsy, and long history of sensorineural hearing loss.
- Closed tympanoplasty is conducted in relatively narrow area. Use diamond burrs from time to time to stop bleeding from the bone.
- Saucerization of the cavity is of utmost importance. Failure in saucerization results in having a small and deep hole. Drilling in that cavity may risk important structures such as the facial nerve and the lateral semicircular canal, and may compromise removal of cholesteatoma matrix.
- If the ossicular chain remains intact, meticulous care should be taken not to touch to the ossicular chain with burrs, especially short process of the malleus in atticotomy and canal calibration. Any touch to the chain may cause sensorineural hearing loss.
- During posterior epitympanotomy, care should be taken not to uncover the dura mater of the tegmen tympani. It might cause CSF leak and eventually, meningoencephalic herniation.
- During posterior epitympanotomy, care should be taken not to fenestrate the superior wall of the external auditory canal. If this happens, reconstruction with cartilage and/or bone paté should be carried out at the end of the procedure.
- If the middle fossa dura is uncovered accidentally, reconstruction of the middle fossa plate with cartilage is fundamental to avoid delayed onset of meningoencephalic herniation. On the other hand, if the middle fossa dura is exposed by cholesteatoma, complete removal of the matrix from the dura is often difficult, or even dangerous in elderly. In such cases, open tympanoplasty to exteriorize that area is indicated (see Chapter 10.2).
- Leave the posterior canal wall as thick as possible. Do not make this wall too thin. Cholesteatoma may eventually arise from that portion. If some fenestration is made, it should be closed with bone paste with/without thin cartilage depending on its size.
- Fenestration in the posterior wall or too thin posterior wall may cause the same complication. The opening should be repaired with the same manner.
- The risk to injure the mastoid segment of the facial nerve can be reduced with a largest possible diamond burr used under continuous suction irrigation. The burr should be moved parallel to the nerve, never perpendicular to it.
- During opening the facial recess (posterior tympanotomy), avoid drilling too anteriorly toward the posterior tympanomeatal angle. Erosion of the bony annulus may follow.
- Do not forget to reconstruct erosion of the superior and/or the posterior bony annulus with cartilage and bone paté.
- Do not forget to place a large piece of medium-thickness Silastic sheeting. The sheeting is inserted from the posterior cavity via posterior tympanotomy toward the eustachian tube. The sheeting covers the entire medial wall of the middle ear including the attic and the antrum.
- Do not remove the lateral portion of the posterior canal wall. This mistake makes the laterally based posterior meatal skin flap (vascular strip) easy to slipping down into the cavity. If this happens, some correction should be necessary at the time of reconstruction (see Chapter 6.1.6).
- Make sure that the posterior meatal skin is long enough to stay in the canal. Short meatal skin causes iatrogenic cholesteatoma if the skin falls into the cavity.
- Preplan the second stage at 10 to 12 months after the first-stage surgery in order to detect residual cholesteatoma, if any.
- Reexplore the mastoid if the cholesteatoma exists in the antrum at the first stage.
- If cholesteatoma matrix has been left in the middle ear (the round window, the oval window, and the large labyrinthine fistula), reexplore the tympanic cavity and the mastoid within 6 months after the surgery.
- If recurrent cholesteatoma is present during the second stage, do not try to maintain the CWU technique.
- Do not hesitate to remove the canal wall and to transform the technique to canal wall down. Do large enough meatoplasty (see Case 7.1 in Chapter 7).
- If there is no recurrent cholesteatoma but the cartilage used for reconstruction of the canal wall in the first stage is atrophic in the second stage, the decision is case by case (in an individualized base). However, close observation is required if canal wall up technique is maintained.
- If residual cholesteatoma is found during the second stage, try to remove it as an intact pearl. If the residual is located in the attic, the antrum, or over the covered facial nerve, drilling of the bone or intensive removal of the mucosa in that area should be conducted to reduce risk of leaving epidermis.
- If residual cholesteatoma is large and there is a risk of leaving matrix behind, it is better to transform the CWU into CWD technique.
- A CWU tympanoplasty for cholesteatoma should be followed up for at least 10 years after the last surgery.

Videos

See Video 6.1, Video 6.2, Video 6.3.

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7 Canal Wall Down Tympanoplasty

Indications

- Cholesteatoma in cases of
 - Contracted mastoid
 - Large epitympanic erosions
 - Recurrence after the closed tympanoplasty
 - Bilateral cholesteatoma
 - Cleft palate and Down's syndrome
 - Only hearing ear
 - Large labyrinthine fistula
 - Severe sensorineural hearing loss

When marked attic erosion is present in cholesteatoma, especially in adults, we perform a canal wall down (CWD; open) technique to avoid cholesteatoma recurrence that can occur due to absorption of the material used for reconstruction of the attic defect. In cases with sclerotic mastoids, or when middle ear atelectasis is present, a CWD tympanoplasty is also performed. The number of CWD techniques performed in our center is gradually increasing. As described, we now use canal wall up (CWU; closed) technique only in limited cases (< 10%) due to its higher percentage of recurrence and residual cholesteatoma. Today, we mainly apply CWD techniques in cholesteatoma surgery. According to our experience, a well-performed CWD cavity has more chance to prevent second operation with minimal declination of hearing and quality of life.

In CWD tympanoplasty, execution of correct technique is the key for successful surgery. In this technique, since posterior wall of the external auditory canal is removed, the mastoid and the external auditory canal became common communicating cavity exposed to outside after surgery. To avoid postoperative complications, it is very important to create an ideal cavity in the first surgery by following correct procedures such as sufficient saucerization of the cavity and appropriate meatoplasty. Saucerization of the entire cavity and removal of any overhang edges not only increase the working space but also allow soft tissue to fill in the bony defect. That makes the cavity smaller without using any material for obliteration. We always perform meatoplasty in CWD techniques, since this technique allows reduction of raw surface and further makes the cavity relatively small and shallow by enlarging its opening. An adequate meatoplasty is an essential prerequisite to obtain constant success in CWD tympanoplasties. If all procedures are properly performed, the cavity appears small, shallow, rounded in shape, dry, and well epithelized.

On the other hand, a badly performed cavity may appear wet, irregular, and difficult-to-reach periphery. The cavity may be lined with granulation tissue covered by accumulated debris. We have found that technical mistakes commonly seen in the failed cavity are a very narrow meatus and insufficient bone removal such as a high facial ridge, an overhanging edge, and a prominent mastoid tip. Each of these factors impedes self-cleansing of cerumen and debris from the cavity, resulting in inflammatory reaction. In addition, possibility of residual and recurrent cholesteatoma is higher in such cavity.

In this chapter, we describe three techniques used in our center.

- If the ossicular chain is severely insulted or the middle ear is involved, we use a CWD tympanoplasty that consists of eradication of the disease from the middle ear with CWD and ossicular chain reconstruction.

- For early epitympanic cholesteatoma in which continuation of articulations between the ossicles is preserved, modified Bondy technique yields best result in a single stage according to postoperative hearing, residual and recurrence rate.
- For elderly patients with nonserviceable hearing and for cholesteatoma in difficult-to-reach area such as deep tympanic sinus, a safe, dry, self-cleaning ear may be the final goal. In such cases, we sacrifice middle ear function by applying radical mastoidectomy that consists of plugging of the eustachian tube and elimination of air space medial to the tympanic membrane.

The patients who have recurrent cholesteatoma tend to have either poor physiologic function of eustachian tube or the most difficult-to-manage disease status. Revision surgery by preserving the canal wall is likely to expense the patient and family to face new surgery. Therefore, once recurrence occurred, we do not hesitate to convert the procedure to CWD technique by removing the posterior canal wall.

7.1 Canal Wall Down Tympanoplasty

7.1.1 Surgical Steps

Removal of the Posterior Canal Wall

1. If CWD tympanoplasty has been planned preoperatively, the mastoidectomy can be performed in two ways. After completing mastoidectomy, the shape of the cavity obtained with two procedures should be the same.
 - a. Transcortical
Simple mastoidectomy and atticostomy is completed from the posterior cavity just like closed technique. Thinned posterior wall may be removed with either burrs or a rongeur.
 - b. Transmeatal
Identify first the middle fossa plate. Enlarge the external auditory canal by following the middle fossa plate posteriorly toward the sinodural angle. The sigmoid sinus is identified at this point. The mastoid cavity is gradually opened from anterior to posterior.
2. The cavity must always be saucerized and gradually deepened. Bony overhangs should be removed from the edges. A round-shaped cavity should be obtained at the end of the drilling.
3. All the bone covering the middle fossa dura and the sigmoid sinus is thinned with large burrs moved parallel to these structures (► Fig. 7.1). If bone is appropriately removed, middle fossa dura is clearly identified through the thinned bone by its pinkish color, and the sigmoid sinus is clearly identified by its bluish color (► Fig. 7.2).
4. Removal and exteriorization of all air cells posterior to the mastoid segment of the facial nerve and the sigmoid sinus is carried out.
5. Sufficient bone removal from the sinodural angle is also a part of the procedure.
6. The facial ridge is lowered evenly by drilling the posterior canal wall with a large cutting burr, with continuous suction irrigation. The burr should be moved always parallel to the course of the facial nerve. Diamond burrs are reserved for final drilling to thin the bony coverage of the nerve. In this procedure,

the nerve is skeletonized laterally until the nerve becomes visible through a thin bony shell, but never exposed (► Fig. 7.3).

7. In the area of the facial bridge, a burr is moved parallel to the middle fossa plate so as not to hit it accidentally with the burr.
8. In poorly pneumatized mastoid frequently seen in chronic otitis media, level of the ideally drilled facial ridge is almost in the same plane of the drilled mastoid cavity.
9. If there is prominent protrusion in anterior or inferior wall, canalplasty should be carried out. The anterior attachment of the facial bridge is lowered sufficiently (► Fig. 7.4). The anterior meatal skin is cut laterally and detached from the bone toward the annulus. The medially folded meatal skin flap is protected with an aluminum sheet (► Fig. 7.5). The anterior and/or the inferior meatal walls are drilled to obtain round-shaped cavity. Care should be taken not to expose the temporomandibular joint beneath the anterior wall.
10. The final shape of the cavity is a reversed pyramid with rounded external edges with no bony overhang in the cavity. Drilling to correct the shape of the cavity should be carried out to such extent.

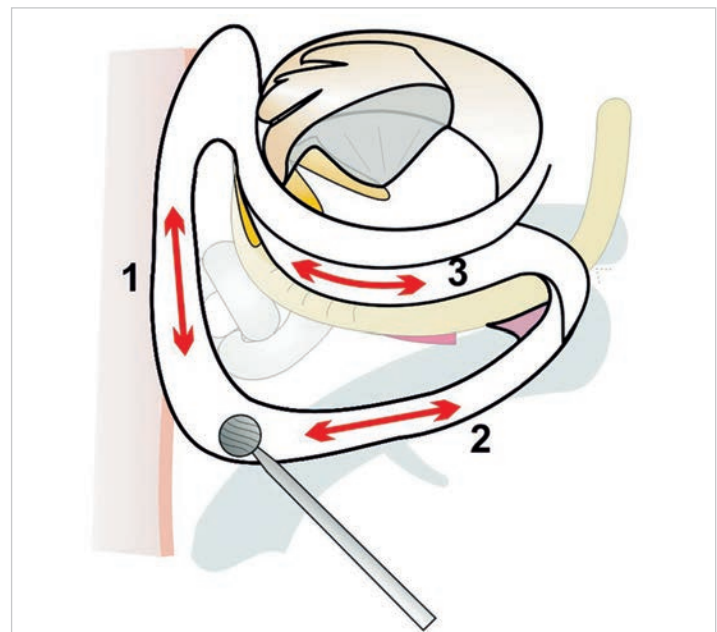


Fig. 7.1 Bone covering the middle fossa dura and sigmoid sinus it thinned using large burrs which should move parallel to those structures.

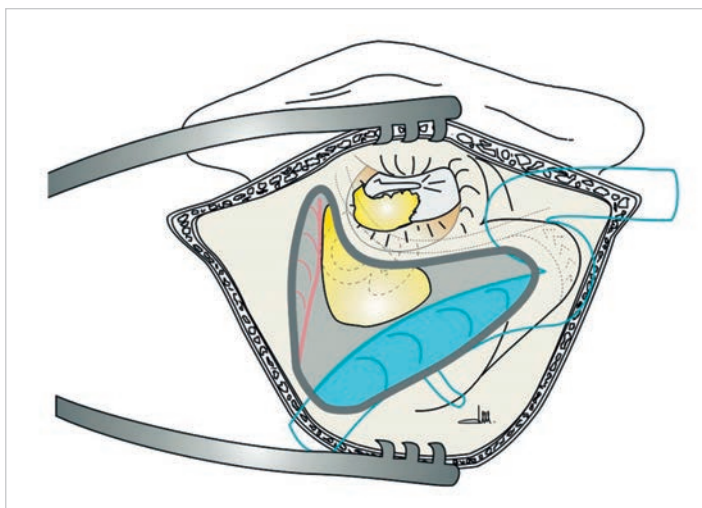


Fig. 7.2 When enough bone is removed, the middle fossa dura will look pink through the bone and the sigmoid sinus blue.

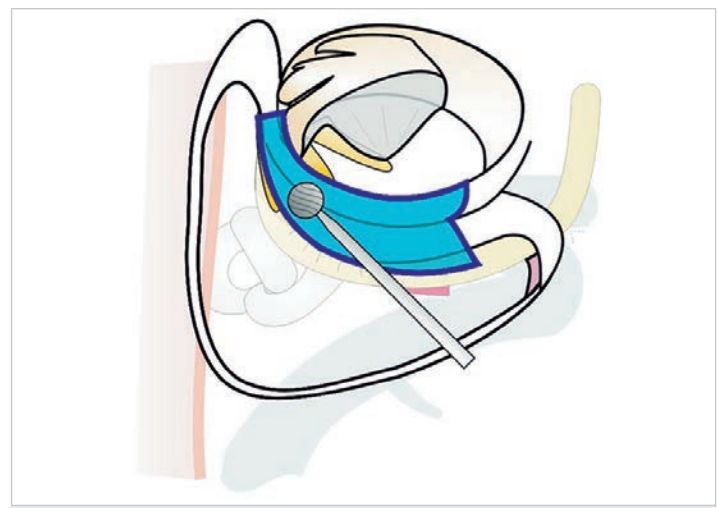


Fig. 7.3 The facial ridge is drilled using a large cutting burr moving parallel to the nerve.

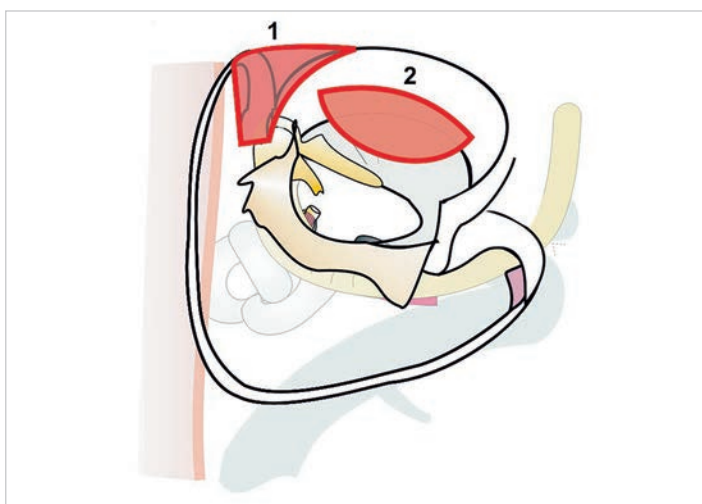


Fig. 7.4 If protruding, the anterior attachment of the facial bridge (1) and the anterior canal wall (2) should be drilled.

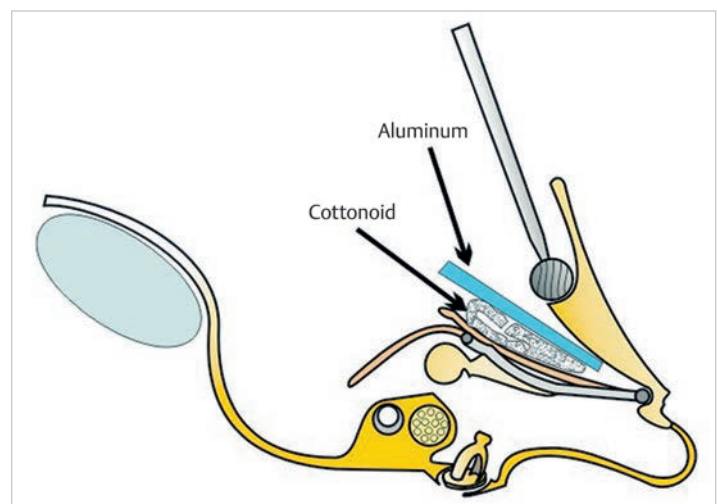


Fig. 7.5 The meatal skin flap and the tympanic membrane should be protected by aluminum when drilling the canal wall.

Management of the Tympanic Cavity

1. Management of the tympanic cavity should be conducted as soon as possible after sufficient and safe access is established. In this way, hemostasis in the tympanic cavity is achieved before starting reconstruction. Bloodless field is very important for correct arrangement of the reconstruction materials. For that sake, some bone work away from the tympanic cavity may be carried out after managing the tympanic cavity.
2. The fibrous annulus is detached from the tympanic sulcus posteriorly, and the tympanomeatal flap is elevated to explore the middle ear.
3. The facial bridge, and then the anterior and posterior buttresses are removed, preferably using a curette (► Fig. 7.6). Removal of the anterior buttress produces a continuous plane between the middle fossa plate and the anterior canal wall (► Fig. 7.4).
4. A bony overhang of the anterior epitympanic recess should be removed to ensure complete control of this area after the surgery. Air cells in this area are removed as much as possible.
5. Pathology should be carefully dissected from the middle ear not to damage the underlying fragile structures such as the facial nerve, the oval and round windows, the stapes, and the labyrinth. If view of such structures is obstructed by the facial ridge, it may be further lowered (► Fig. 7.7, ► Fig. 7.8). The skin of the external auditory canal, the annulus, tympanic membrane, the incus, and/or the malleus may be removed depending on the status of the lesion (► Fig. 7.9).
6. When ossiculoplasty is planned, the handle of the malleus and the tendon of the tensor tympani muscle are preserved if possible. Those structures give adequate support to the columella and provide better hearing result.
7. If the body of the incus is involved but the incudostapedial joint remains intact, cutting the incus in the long process is preferred (► Fig. 7.10). The remaining portion of the incus may serve as a columella if the facial ridge is lowered sufficiently (► Fig. 7.11).
8. To stop bleeding for reconstruction procedures, the tympanic cavity is momentarily packed with small cottonoids after completing management of it.

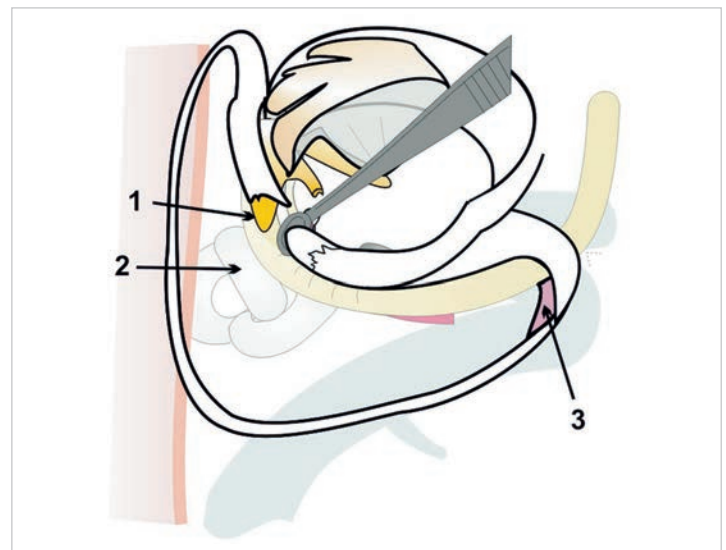


Fig. 7.6 Landmarks for the facial nerve are shown. 1, short process of the incus; 2, lateral semicircular canal; 3, digastric ridge.

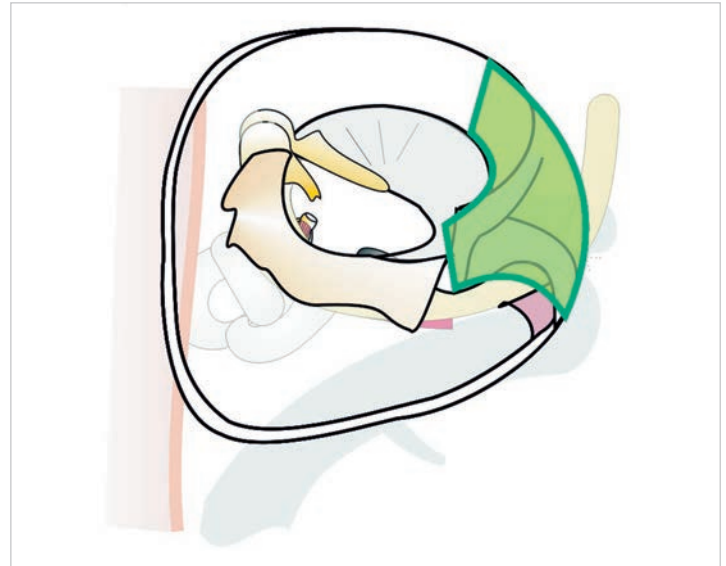


Fig. 7.7 If obstructing the view, the facial ridge (green area) should be lowered.

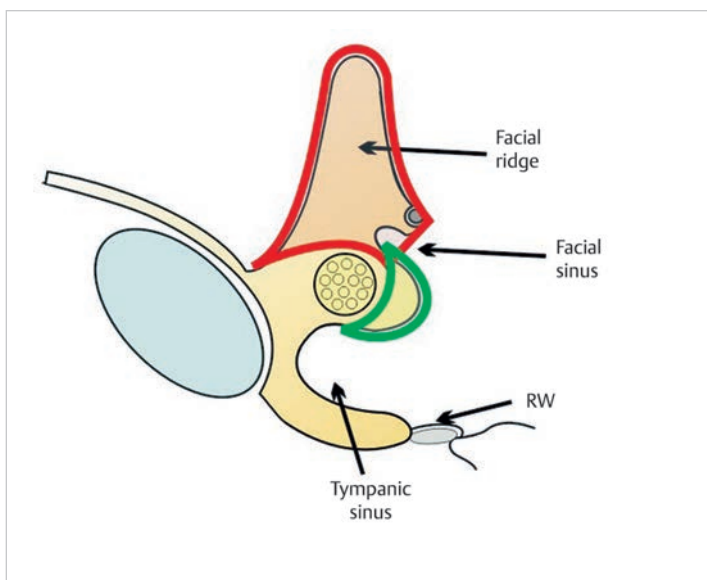


Fig. 7.8 View of the extent of lowering the facial ridge. RW, round window.

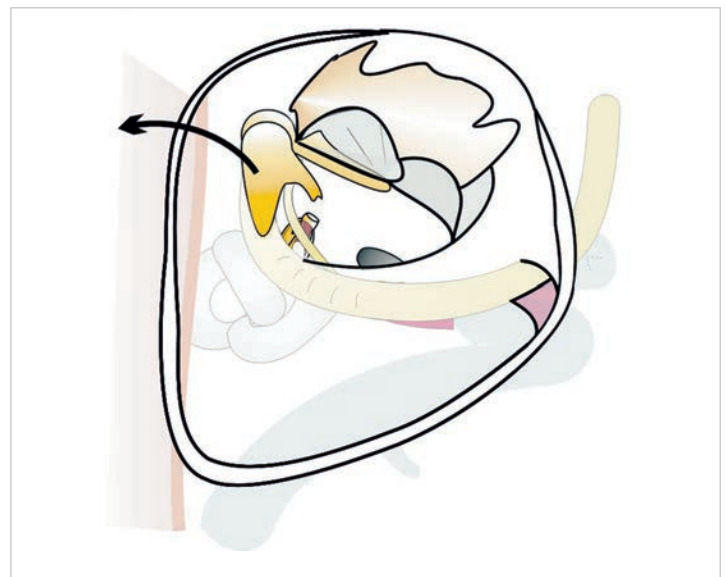


Fig. 7.9 Removal of middle ear structures depends on the pathology in this case. The long process of the incus is eroded and thus removed.

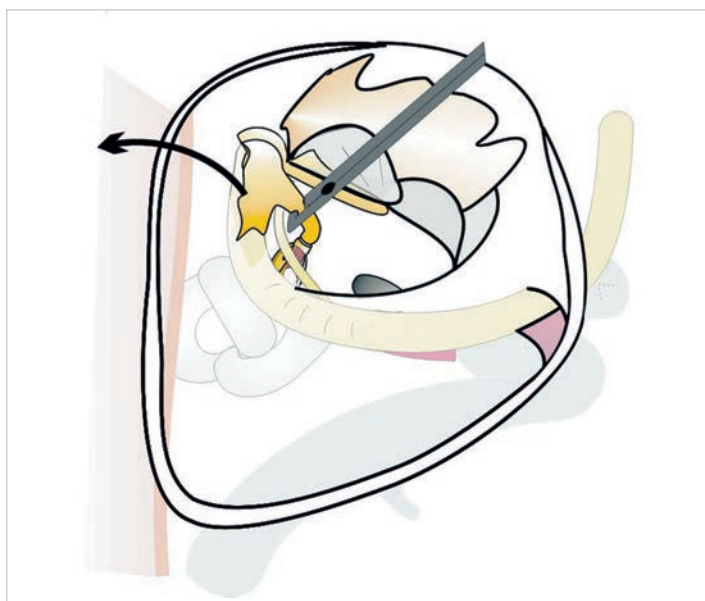


Fig. 7.10 When the body of the incus is involved but the incudostapedial joint is intact, we cut the incus at the long process.

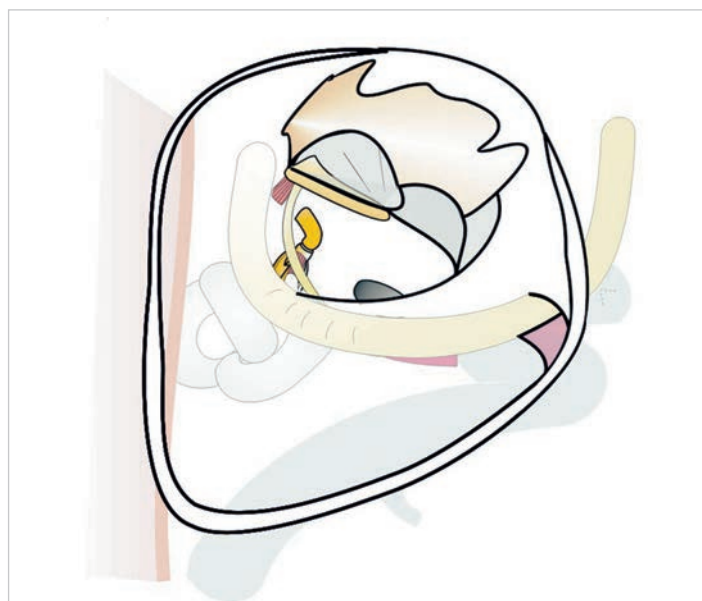


Fig. 7.11 The remnant of the incus may act as a columella to restore hearing.

Management of Pneumatized Temporal Bones

1. In highly pneumatized mastoid, any invaginated areas and air cells, especially perilyabyrinthine and retrofacial cells (► Fig. 7.12) and cells in attic, should be drilled to complete removal of matrix and to avoid postoperative accumulation of skin debris.
2. The retrofacial cells are exenterated completely. During this maneuver, care should be taken not to damage the mastoid segment of the facial nerve. Sometimes, in a highly pneumatized mastoid, the retrofacial cells reach the area of the jugular bulb, medial to the facial nerve.
3. In some cases, the retrofacial cells go far medially to the facial nerve, making complete exteriorization impossible. That area must be obliterated with autologous conchal cartilage.
4. A prominent, well-pneumatized mastoid tip should be removed to reduce volume of the mastoid cavity (► Fig. 7.13). Drilling starts from the level of the stylomastoid foramen, and continues posteriorly in a rotatory fashion parallel to the digastric ridge until the tip is undermined. It is important to create a fracture line lateral to the stylomastoid foramen to avoid any traction of the facial nerve in the following process. The remaining bony shell is mobilized and pulled out in a rotatory fashion with a bone rongeur, and detached from the muscle using electrocautery. This amputation of the mastoid tip not only reduces the cavity volume, but also prevents "sink trap effect" that may cause postoperative accumulation of skin debris.
5. In well-pneumatized bone, large retrosigmoid air cells should also be removed if they are present (► Fig. 7.14).
6. Conchal cartilage harvested in meatoplasty, bone paté mixed with blood, and subcutaneous connective tissue are the materials for the obliteration. If the head of the malleus and the body of the incus are not present or removed, the attic may be obliterated with a piece of cartilage and bone paté.
7. Sometimes, a retroauricular soft tissue flap based anteroinferiorly is used to obliterate the area of the mastoid tip (see ► Fig. 7.53).

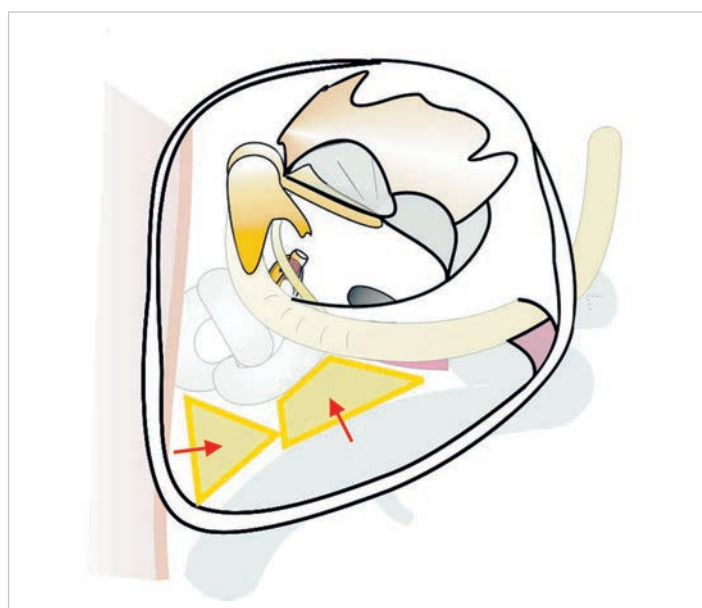


Fig. 7.12 Perilyabyrinthine and retrofacial air cells are shaded in yellow.

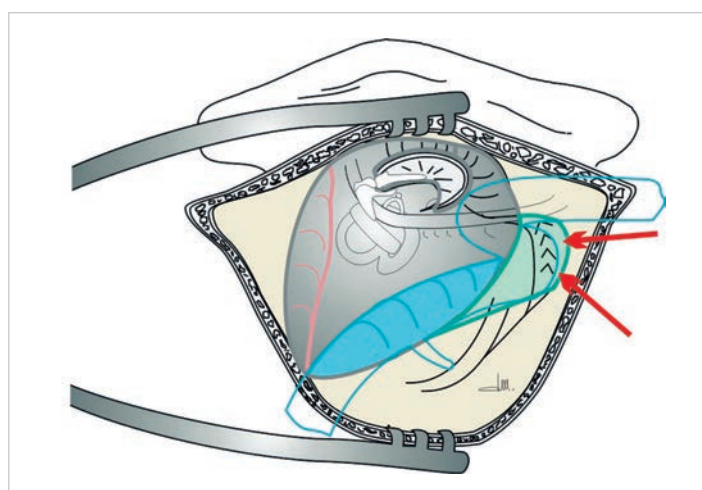


Fig. 7.13 When prominent and well pneumatized, the mastoid tip should be removed.

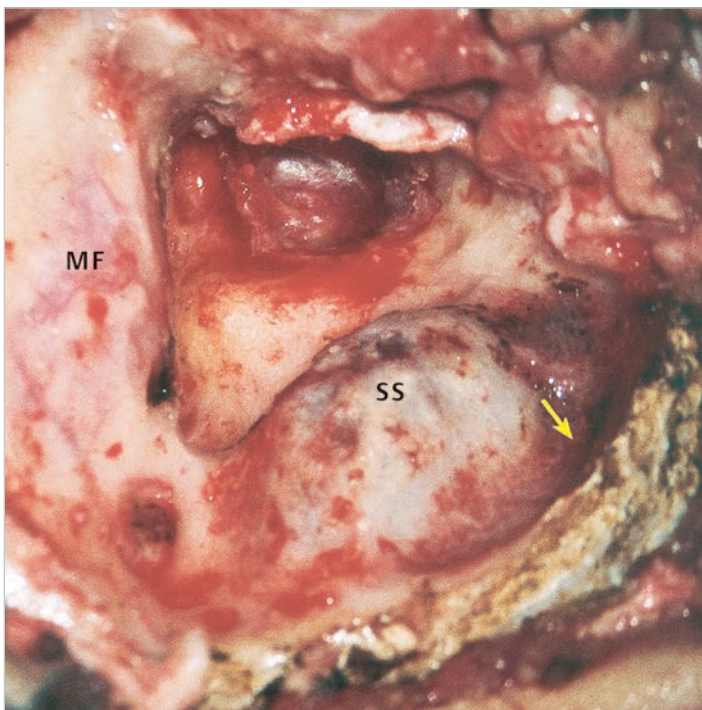


Fig. 7.14 Highly pneumatized mastoid with anteriorly located sigmoid sinus. To obtain a good cavity, removal of the air cells posterior to the sigmoid sinus (arrow) is required in this case. MF, middle fossa; SS, sigmoid sinus.

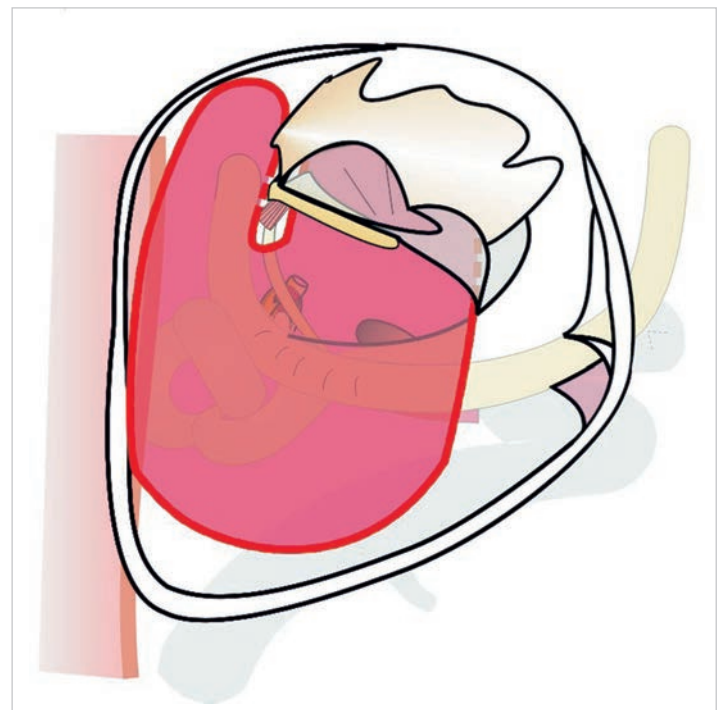


Fig. 7.15 The fascia is cut longitudinally at the edge. One tongue is placed over the attic and the other inferior to the tendon of the malleus muscle in the middle ear cavity.

Reconstruction

1. Before reconstructing the tympanic membrane, bleeding should be completely stopped. If tubal dysfunction is suspected, a Silastic sheeting designed to cover the medial wall of the tympanic cavity including the tubal orifice is placed. The eustachian tube and the tympanic cavity are packed with Gelfoam.
2. The temporalis fascia is grafted underlay whenever it is possible. The overlay technique is used when the anterior annulus is not present. The graft must have abundant extension posteriorly to cover attic and obliterated cells, especially if an ossiculoplasty is performed in the same stage. Another piece of graft may be placed to cover exposed bone. Epithelization is facilitated if the exposed bone is covered with the fascia.
3. If the tendon of the tensor tympani with the manubrium is preserved, a longitudinal cut is made in the edge of the temporalis fascia. One tongue is placed on the attic and goes into the protympanum, superiorly to the tendon. The other tongue is inserted inferiorly to the tendon, and placed in the tympanic cavity (► Fig. 7.15).
4. If the stapes superstructure is present and the facial ridge is sufficiently lowered, the fascia usually touches to the head of the stapes, and second-stage ossiculoplasty may not be required. A thin piece of cartilage placed over the stapes may be helpful. If the incudostapedial joint is left intact, additional height of the long process of the incus over the superstructure may give sufficient contact with the tympanic membrane. If the height is insufficient, a piece of cartilage may be interposed (► Fig. 7.16).
5. A meatoplasty should be performed in all the cases. (see Meatoplasty in this chapter).

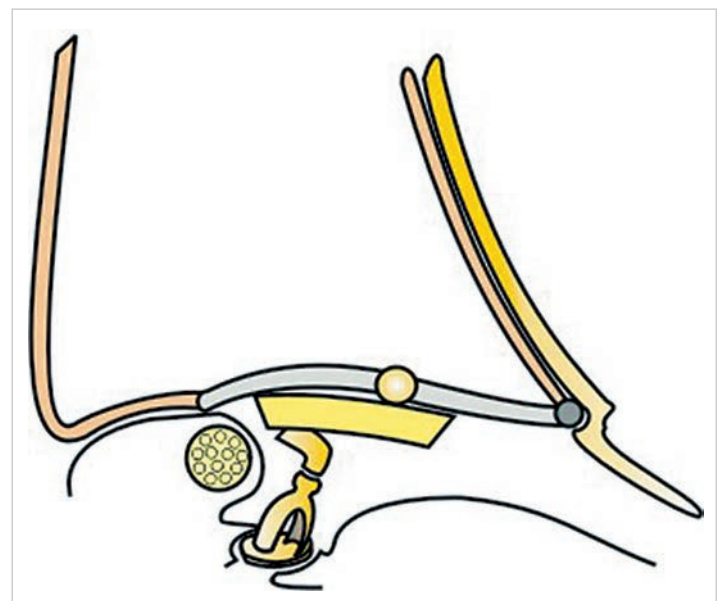


Fig. 7.16 When the height of the left part of the incus is insufficient, it could be augmented using a cartilage graft.

An experienced surgeon can remove cholesteatoma with CWU technique. However, by removing the posterior wall, wide and safe access to the middle ear can be established without having a big cavity (see ► Fig. 7.17a, b)

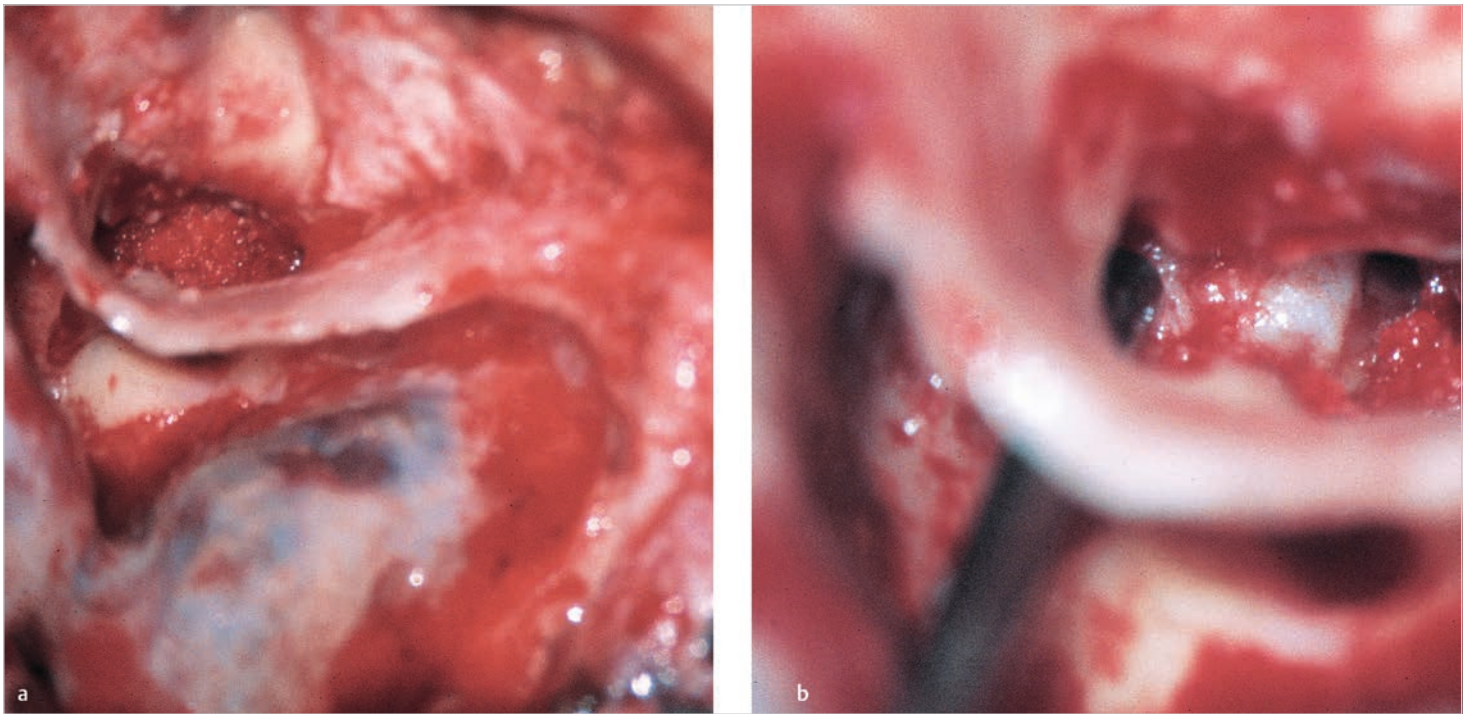


Fig. 7.17 (a) A case of contracted mastoid. (b) Dissection of cholesteatoma through contracted mastoid.

Meatoplasty

After open techniques, the meatus and the mastoid become a common cavity that is much larger than the original meatus. That makes deep, difficult-to-reach area where self-cleansing or even cleaning in the outpatient clinic is difficult from the original meatus. Accumulation of epithelial debris may cause undesirable repetitive inflammation and even cholesteatoma. In our series of revision, open tympanoplasty formerly operated in elsewhere, meatal stenosis is found in about 60% of failed cavity. To avoid cavity problem, we always perform meatoplasty in open techniques. In this procedure, the meatal skin is folded medially and the opening is enlarged to obtain relatively small, shallow, and easy-to-access cavity. The procedure also covers the cavity with skin, which enhances postoperative healing. After complete epithelization, no special restriction is required including water sports and travel. We believe an adequate meatoplasty that suits the dimension of the cavity is an essential prerequisite to obtain successful result steadily in open tympanoplasties.

1. Meatoplasty is performed after completing mastoidectomy in every case in which open technique is conducted to adjust the size of the meatus to the cavity.
2. If conchal cartilage is required for reconstruction, the cavity is packed with cottonoids to achieve complete hemostasis and to prevent blood filling the cavity before starting meatoplasty. If reconstruction is completed, the cavity, especially in the area of tympanic membrane, should be partially packed with the Gelfoam to secure reconstructed structures. Small cottonoids are placed over it. After removing self-retaining retractors, folded gauze is placed on the retroauricular wound to prevent blood from falling down into the cavity. The auricle is positioned in its original place.
3. Using a nasal speculum, the concha is stabilized. The conchal incision is made from the surface of the auricle (►Fig. 7.18). The skin, conchal cartilage, and connective tissue are incised

together from the middle of posterior meatal wall toward the anthelix, in parallel to the crus of helix (►Fig. 7.19). Length of the incision required depends on the size of the cavity (larger cavity requires longer incision). At least, the digit finger should pass easily after removing conchal cartilage. The incision, however, never reaches the anthelix.

4. The skin is held with forceps and dissected from the underlying cartilage using sharp tympanoplasty scissors (►Fig. 7.20). Then, soft tissue beneath the cartilage is also detached from it (►Fig. 7.21). After exposing sufficient amount of cartilage, it is removed, triangular in shape, from each side of the edges (►Fig. 7.22). The amount of cartilage removed varies depending on the size and contour of the cavity. However, it is important to preserve cartilage in the crus of the helix. Otherwise, cosmetic deformity may follow.
5. If the removal is insufficient, the cartilage can be removed from the retroauricular wound. The auricle is folded anteriorly and held by a scrub nurse. The cartilage is further trimmed by removing a crescent-shaped piece from the edge. Sufficient removal of the cartilage facilitates folding of the skin medially, which serves not only for reducing raw surface in the cavity but also for preventing postoperative perichondritis caused by inappropriate exposure of the resected edge in the wound. To further facilitate medial folding, the skin flaps may be thinned by trimming subcutaneous soft tissue.
6. From the retroauricular wound, the meatal skin flaps are folded posteriorly (►Fig. 7.23), and ideal position for the cavity is estimated. These flaps are finally sutured superiorly and inferiorly to the musculo-periosteal layer with 3/0 Vicryl (►Fig. 7.24). Make sure that the raw surface in the edge of the cartilage is fully covered by conchal skin or soft tissue.
7. After suturing the meatal skin flaps, center of the entire conchal cartilage may be pulled posterosuperiorly and postero-inferiorly. This may cause anterior rotation of the entire auricle, making the auricle prominent postoperatively. Useful technique to avoid this cosmetic problem is to put a couple of sutures deeply in soft tissue more lateral to the meatus, and retract the auricle posteriorly.

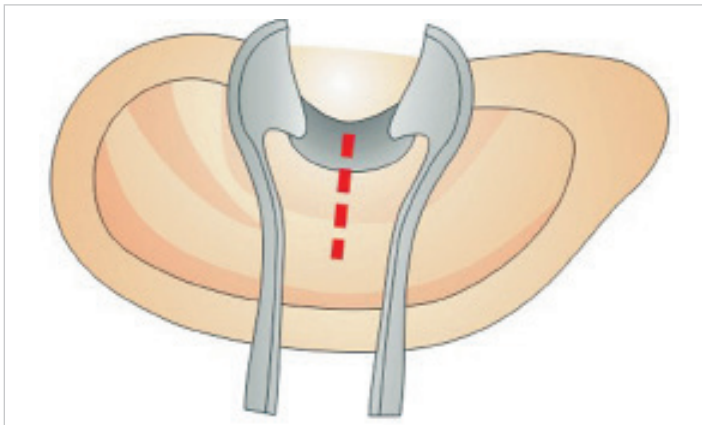


Fig. 7.18 A dotted line demonstrates the site of incision.

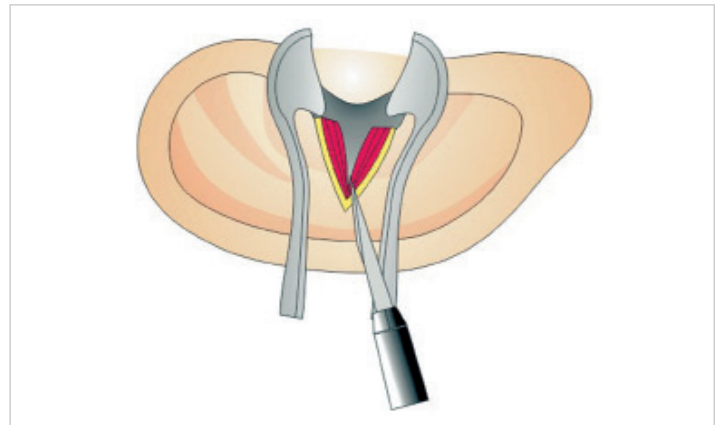


Fig. 7.19 The skin, conchal cartilage, and connective tissue are incised parallel to the crus of the helix.

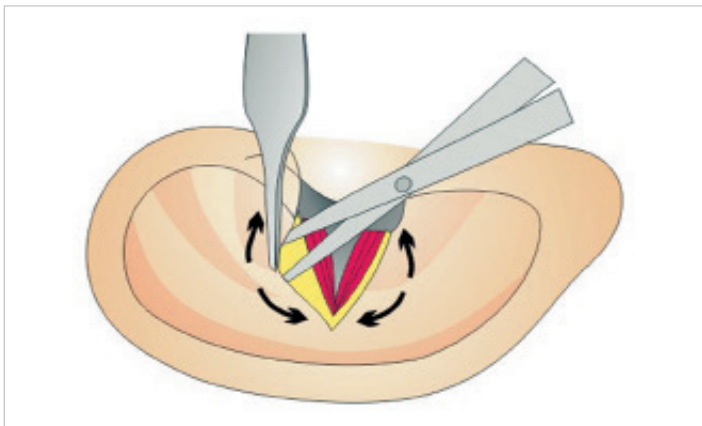


Fig. 7.20 The skin is held with forceps and dissected from the underlying cartilage using sharp tympanoplasty scissors.

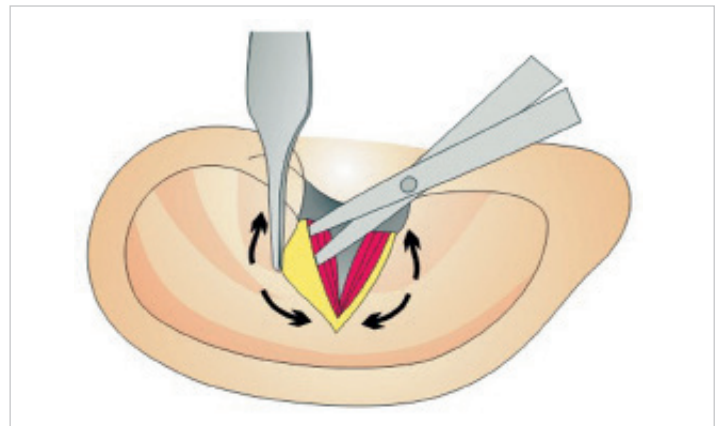


Fig. 7.21 Dissecting conchal cartilage from the underlying connective tissues.

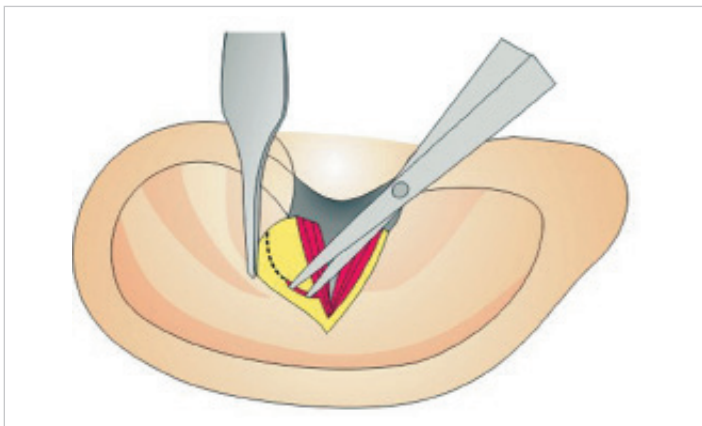


Fig. 7.22 Triangular areas of cartilage are removed.

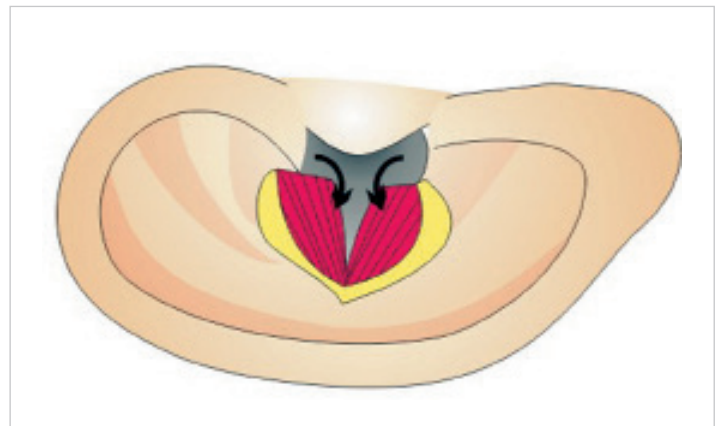


Fig. 7.23 The ideal position for the flaps is estimated.

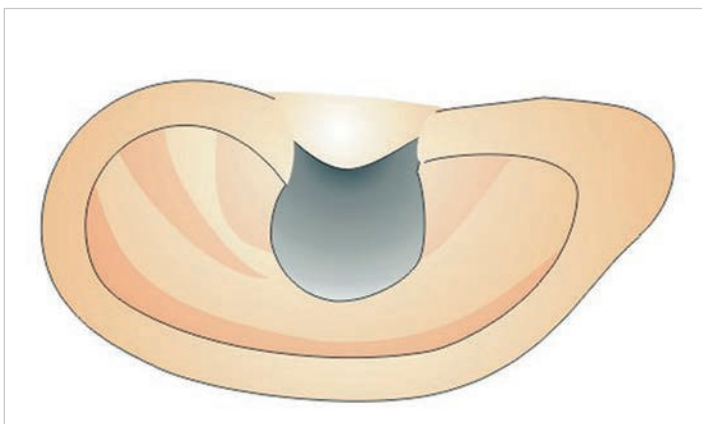


Fig. 7.24 The shape of the meatoplasty after suturing skin flaps.

Case 7.1 (Right Ear): Procedures of Meatoplasty

See ► Fig. 7.25, ► Fig. 7.26, ► Fig. 7.27, ► Fig. 7.28, ► Fig. 7.29, ► Fig. 7.30, ► Fig. 7.31, ► Fig. 7.32.

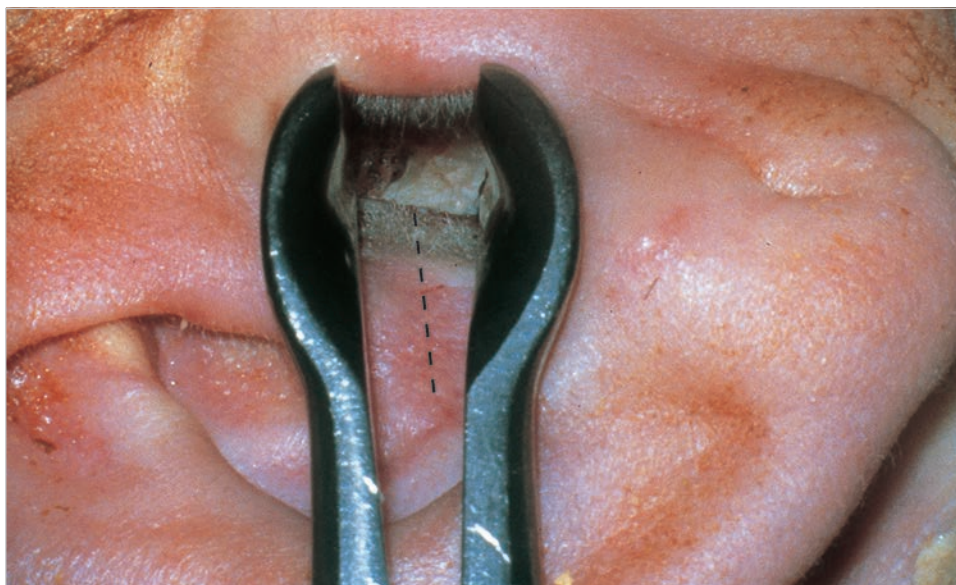


Fig. 7.25 To obtain a dry self-cleaning canal wall down cavity constantly, meatoplasty is of tremendous importance, and it should be performed in all cases. After finishing all bone works, a piece of folded gauze is put over the cavity to prevent blood running into the cavity, and the auricle is placed back. The concha is stabilized with a nasal speculum. The dotted line indicates incision line in the concha.



Fig. 7.26 A cut is made with a Beaver's blade including the underlying conchal cartilage. The cut runs almost parallel to the crus of the helix, toward the anthelix.

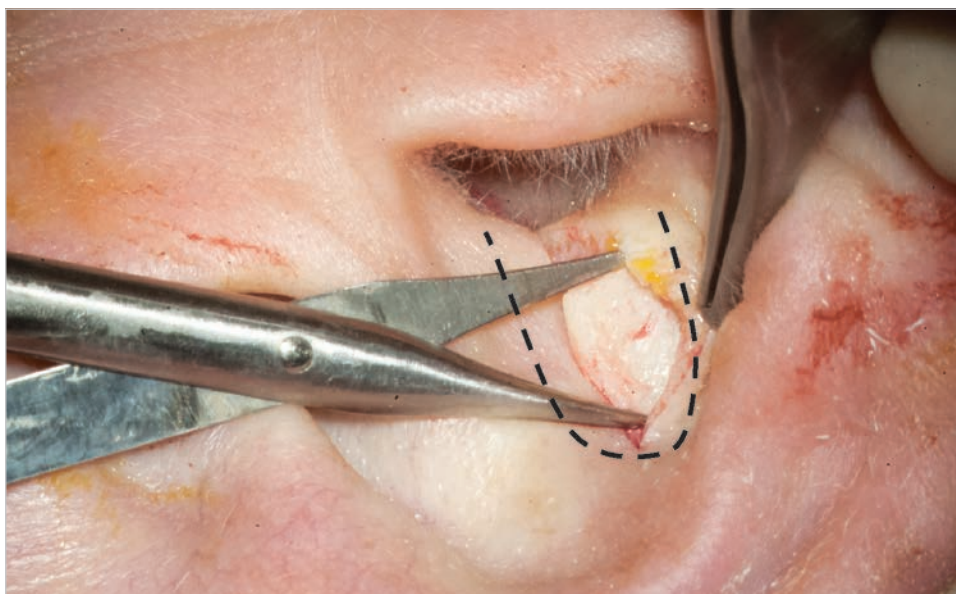


Fig. 7.27 The conchal cartilage is dissected from subcutaneous tissue with scissors to expose sufficient area. Since the cartilage is fragile, it is wise to hold the skin, not the cartilage during this procedure. The cartilage to be removed is indicated by the dotted line.

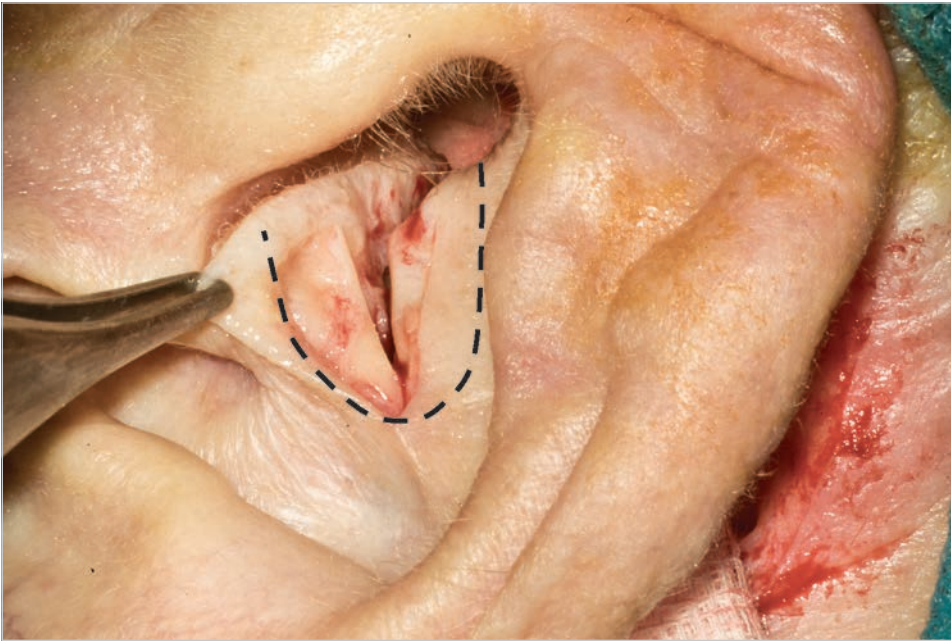


Fig. 7.28 Dissection of the cartilage from the skin of the concha is on the way.



Fig. 7.29 The conchal cartilage is resected from the inferior edge, and taken out. The cartilage in the superior edge will be removed in the same manner.



Fig. 7.30 The auricle is reflected anteriorly, and the concha is viewed from the retroauricular wound. If not enough cartilage has been removed from lateral, the removal can be augmented from this side. In this case, the conchal cartilage is sufficiently removed to open the meatus widely.

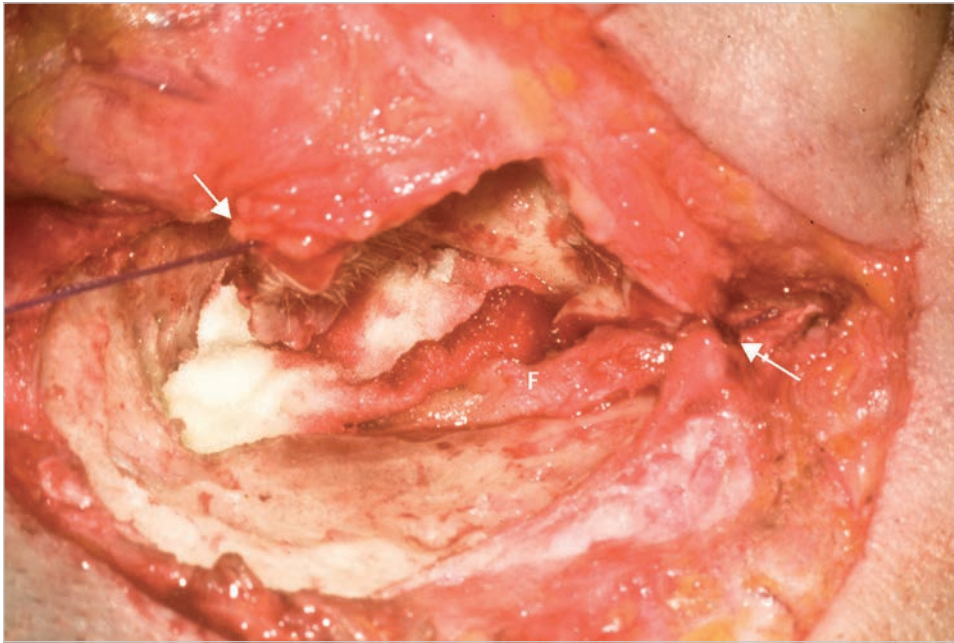


Fig. 7.31 To open the meatus widely, two flaps in the concha should be sutured (*arrows*) to the subcutaneous tissue at the end of the surgery. Suture of the superior flap is in progress. F, soft tissue flap.



Fig. 7.32 When adequately sutured, the meatus keeps its shape by itself. After suturing of the retroauricular wound in two layers, the enlarged meatus is packed with Gelfoam to ensure intimate attachment to subcutaneous tissue and underlying bone.

Packing and Closure

The cavity is packed with Gelfoam soaked in physiologic saline. Generally, no antibiotic ointment is used. The retroauricular incision is closed by suturing the skin in two layers, or in one layer with Steri Strip. Usually, after radical mastoidectomy and modified Bondy technique, second-stage operation is not necessary. Epithelization of the cavity is completed within 8 weeks in most of the cases.

7.1.2 One-Stage Surgery in Canal Wall Down Tympanoplasty

As mentioned, staged surgery where cholesteatoma is removed in the first stage and removal of residual disease, if any, and reconstruction of ossicular chain are performed in the second stage

usually gives better hearing result. Status of mucosa around the oval window and stability of the previously reconstructed tympanic membrane mainly give such difference. The second-stage surgery can be carried out easily under an ear speculum under local anesthesia as far as the first-stage canal wall down procedure is conducted correctly giving sufficient access to the tympanic cavity. Main drawbacks of such strategy are necessity of the other surgery and postoperative hearing disturbance. In limited cases, one-stage surgery is preferred especially in better hearing ear with healthy mucosa in the tympanic cavity especially around the stapes. In marginal cases to which modified Bondy technique might be applied, actual surgical procedure is decided in the operating field. If there is any uncertainty of complete removal from the area medially to the ossicular chain, the surgeon should remove some part of ossicular chain. Since mucosa in the tympanic cavity usually keeps good condition, such cases are good candidates for one-stage surgery.

Case 7.2 (Right Ear)

See ▶ Fig. 7.33, ▶ Fig. 7.34, ▶ Fig. 7.35, ▶ Fig. 7.36, ▶ Fig. 7.37, ▶ Fig. 7.38, ▶ Fig. 7.39, ▶ Fig. 7.40, ▶ Fig. 7.41, ▶ Fig. 7.42, ▶ Fig. 7.43, ▶ Fig. 7.44, ▶ Fig. 7.45, ▶ Fig. 7.46, ▶ Fig. 7.47, ▶ Fig. 7.48, ▶ Fig. 7.49, ▶ Fig. 7.50, ▶ Fig. 7.51, ▶ Fig. 7.52, ▶ Fig. 7.53, ▶ Fig. 7.54, ▶ Fig. 7.55, ▶ Fig. 7.56, ▶ Fig. 7.57, ▶ Fig. 7.58.

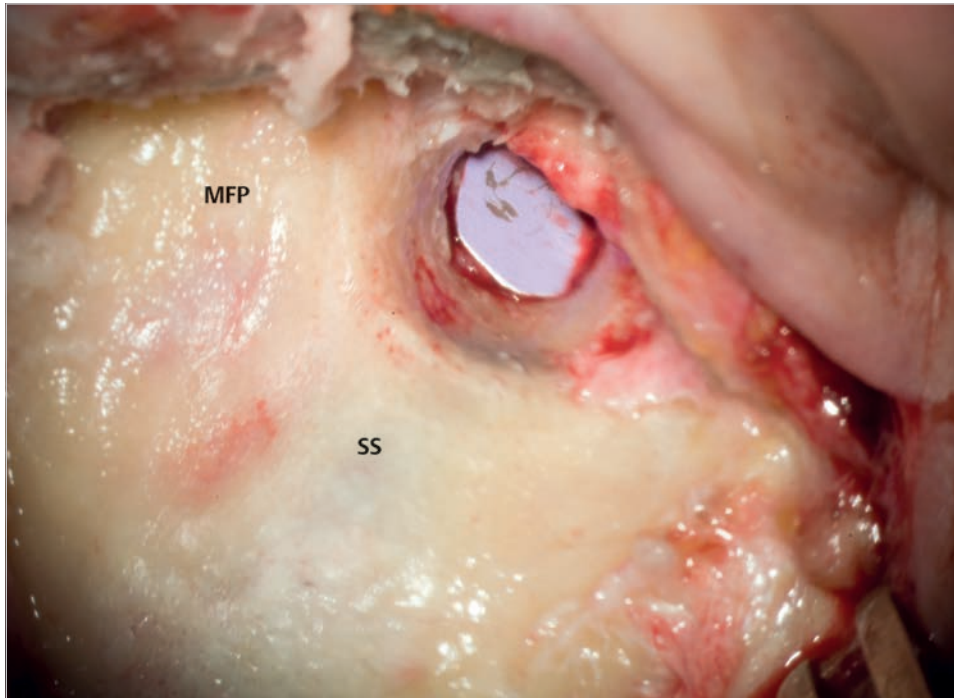


Fig. 7.33 The surface of the mastoid is exposed through a retroauricular incision. The bluish area just posterior to the external auditory canal corresponds to the sigmoid sinus, and the pinkish area superior to it corresponds to the middle fossa dura. Very narrow area is left between two structures. The tympanomeatal flap is protected with aluminum sheeting. MFP, middle fossa plate; SS, sigmoid sinus.



Fig. 7.34 The posterior meatal skin is detached medially to reach the area of the tympanic membrane. Note that the sigmoid sinus and the middle fossa dura touch to the posterior canal wall. The orifice of the cholesteatoma eroding the attic is seen (arrow).

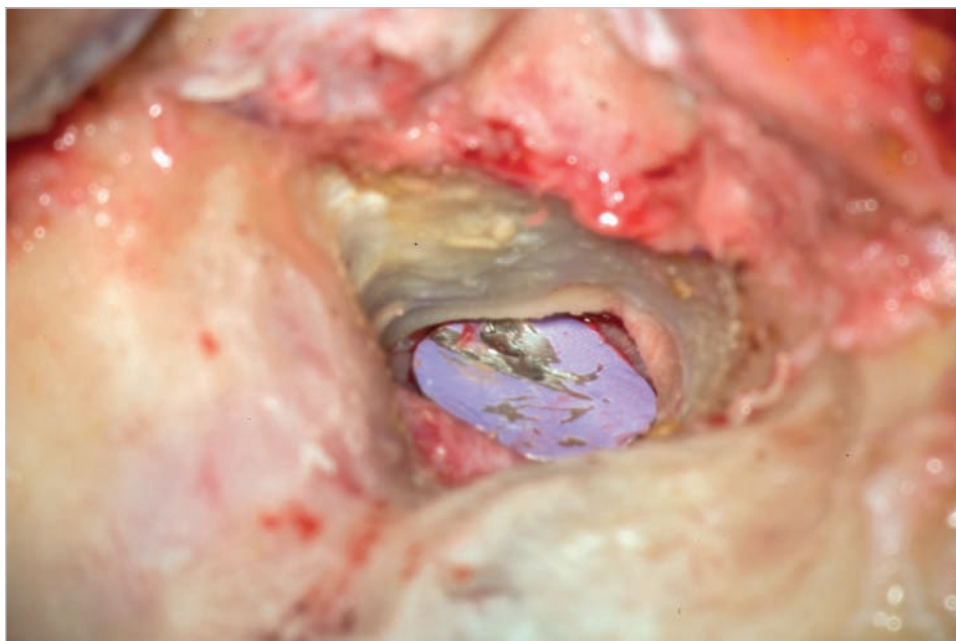


Fig. 7.35 After detaching the anterior meatal skin, canaloplasty is carried out. An aluminum sheeting is used to protect the meatal skin and the ossicular chain. Note that there is still some bone remaining in the anterior wall.



Fig. 7.36 Drilling of the anterior wall is advanced medially to visualize the fibrous annulus (arrow).

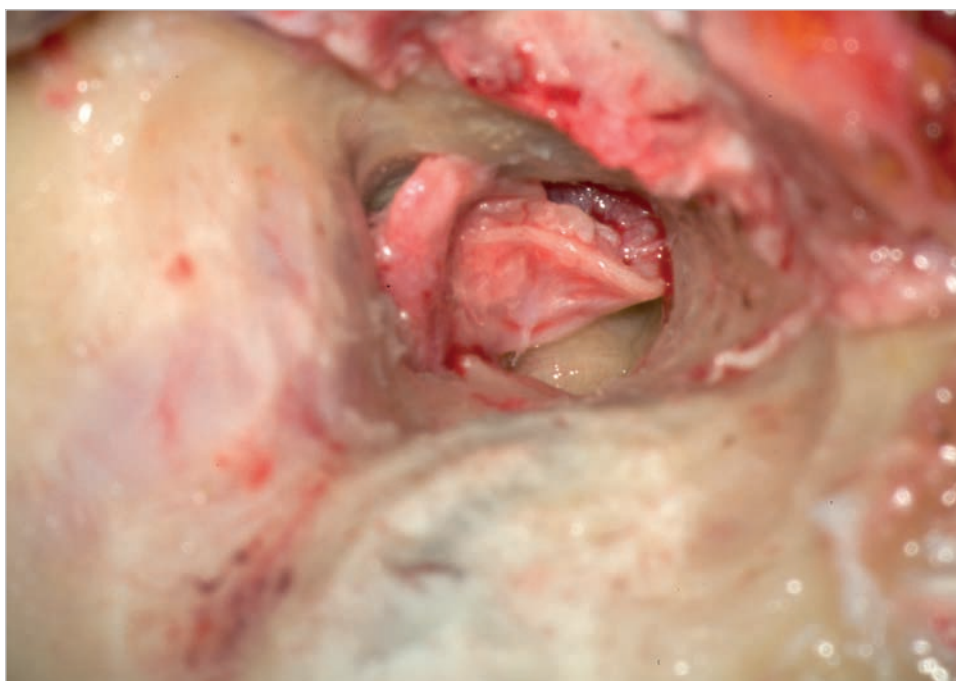


Fig. 7.37 The fibrous annulus is detached from the bony annulus to ensure absence of cholesteatoma.

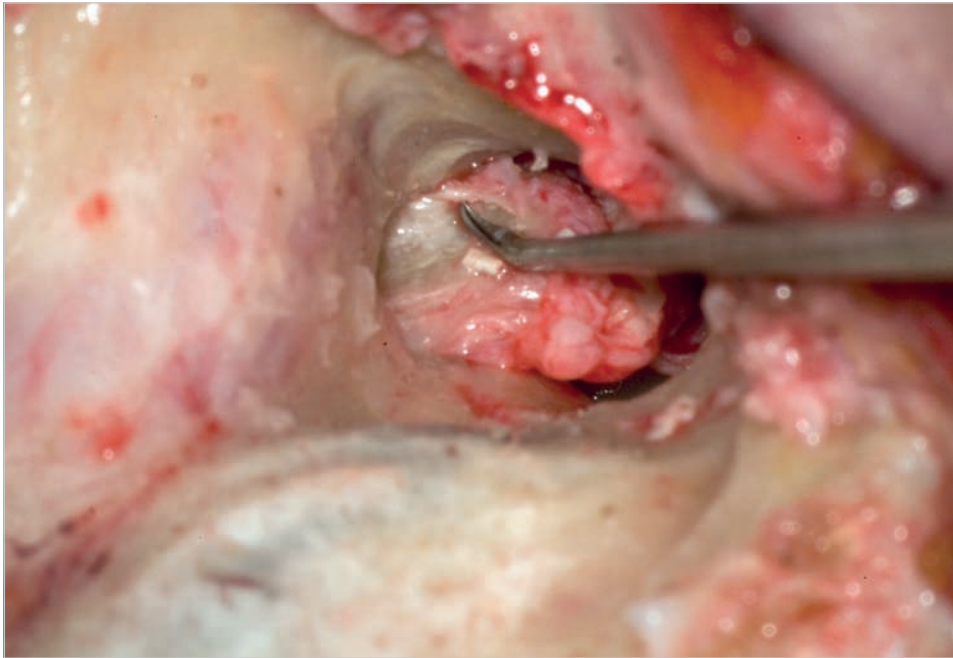


Fig. 7.38 The orifice of the cholesteatoma is shown by pushing the matrix inferiorly. Note that the attic is not accessible without removing the posterior wall.



Fig. 7.39 With a cutting burr, the orifice of cholesteatoma is enlarged.

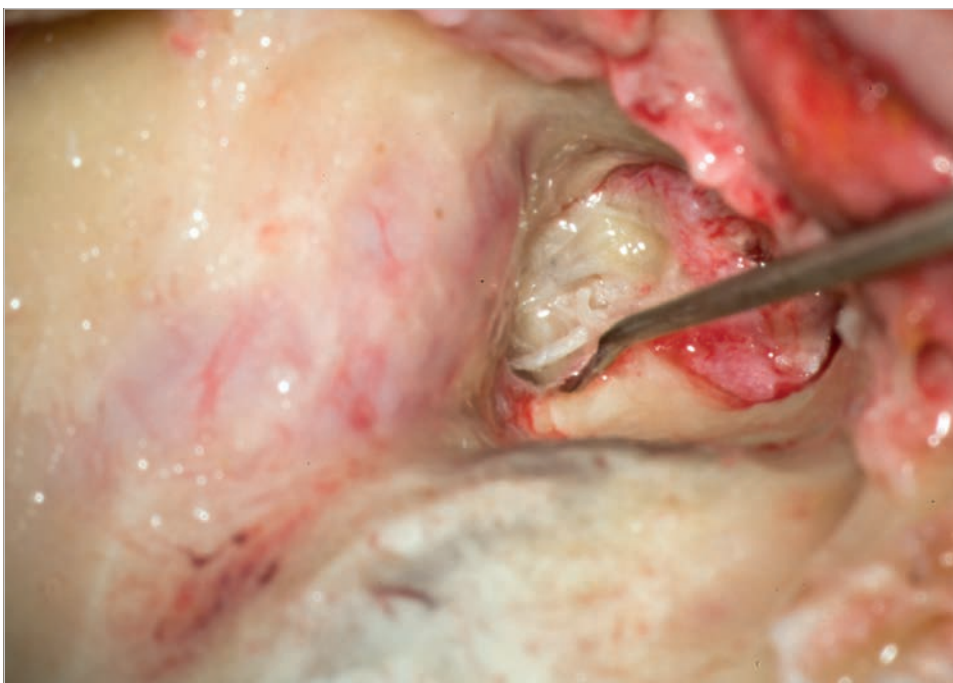


Fig. 7.40 The matrix is opened. The amount of the bone to be drilled is estimated, and location of the ossicular chain is verified with the dissector.

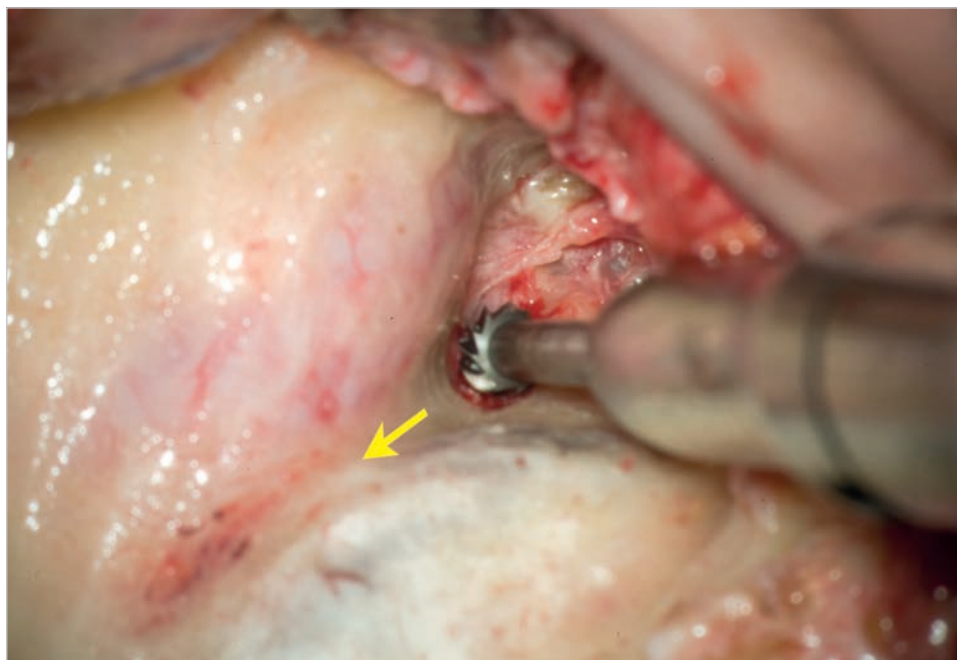


Fig. 7.41 The atticotomy is enlarged along the sinodural angle. To avoid touching to the ossicular chain, the drill should be moved from medial to lateral (*arrow*).

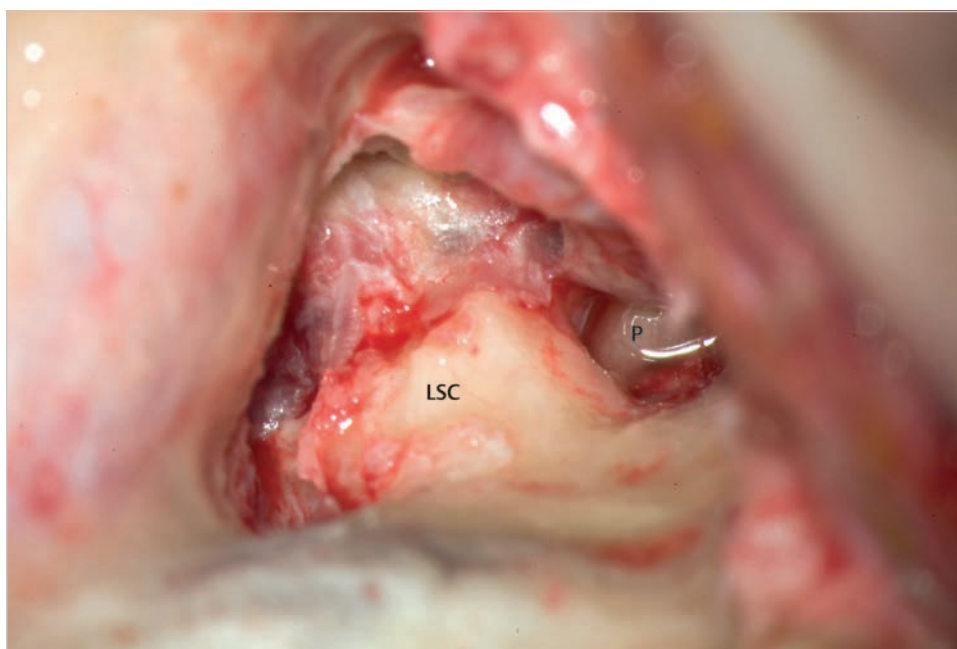


Fig. 7.42 The antrum is opened. Thin matrix covering the medial wall is seen. LSC, lateral semicircular canal; P, promontory.

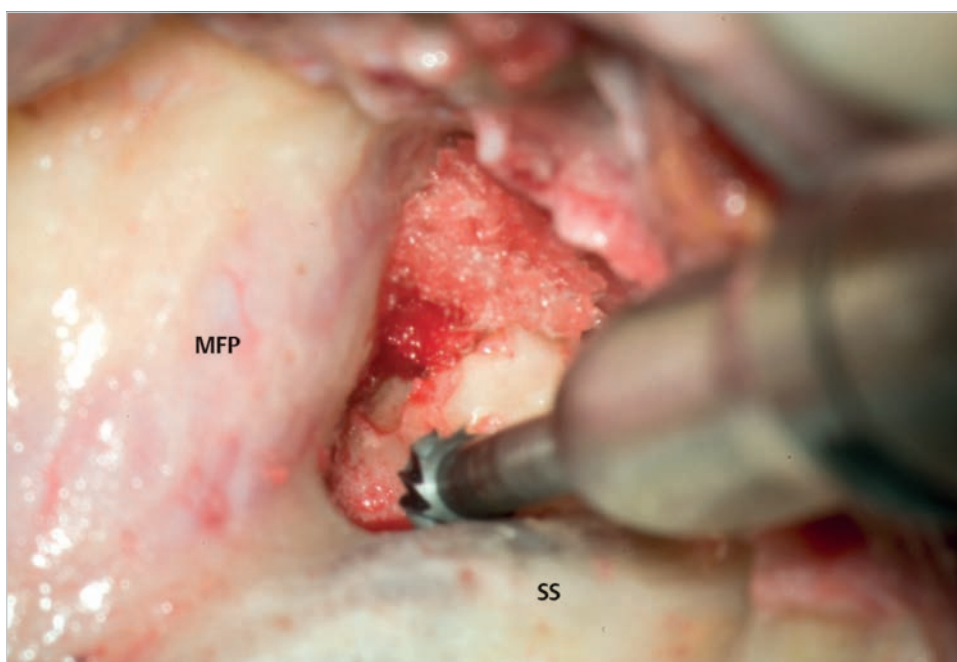


Fig. 7.43 The air cells should be removed as much as possible to ensure removal of the cholesteatoma matrix. Note the narrow approach limited by the two major structures, the sigmoid sinus and the middle fossa dura. Great care should be taken not to damage the sigmoid sinus and the dura medially to the protrusions. The attic is packed with cottonoid for hemostasis. MFP, middle fossa plate; SS, sigmoid sinus.



Fig. 7.44 The matrix is removed from the antrum.



Fig. 7.45 The facial ridge is lowered with a diamond burr.



Fig. 7.46 The posterior buttress has been removed, to visualize the incus. Because of the extension of the cholesteatoma reaching anteriorly to the head of the malleus, the incudostapedial joint is disarticulated.

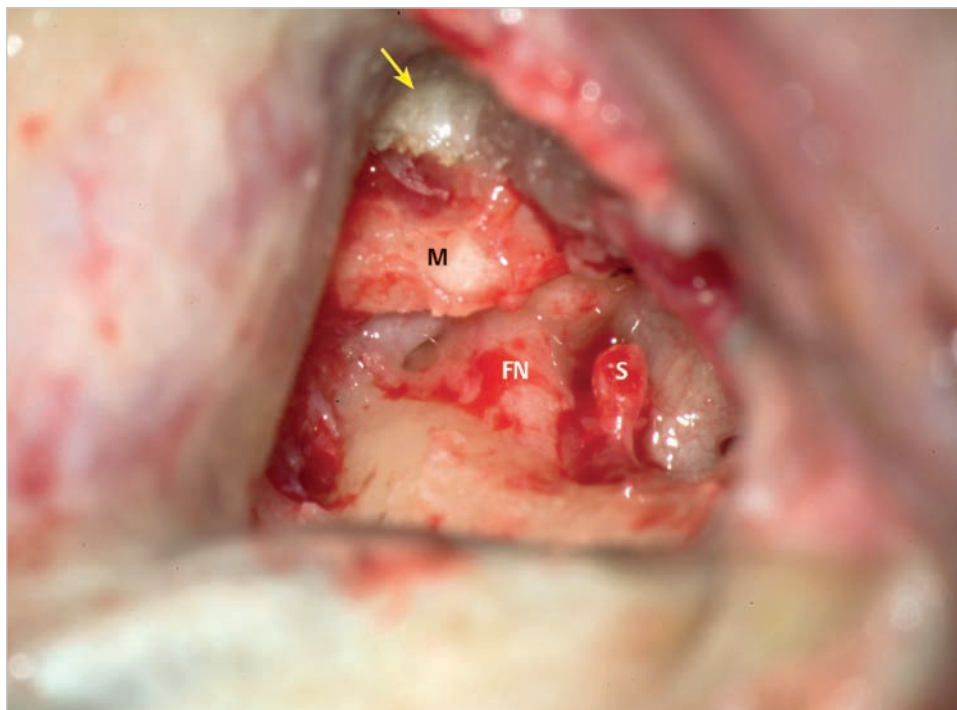


Fig. 7.47 Removal of the incus is completed. No cholesteatoma is seen medially to the incus. The cholesteatoma is seen invaginating the supratubal recess (*arrow*). FN, facial nerve; M, head of malleus; S, stapes.



Fig. 7.48 The head of the malleus is cut with the malleus nipper to open the supratubal recess.



Fig. 7.49 The bone covering the cholesteatoma is removed.

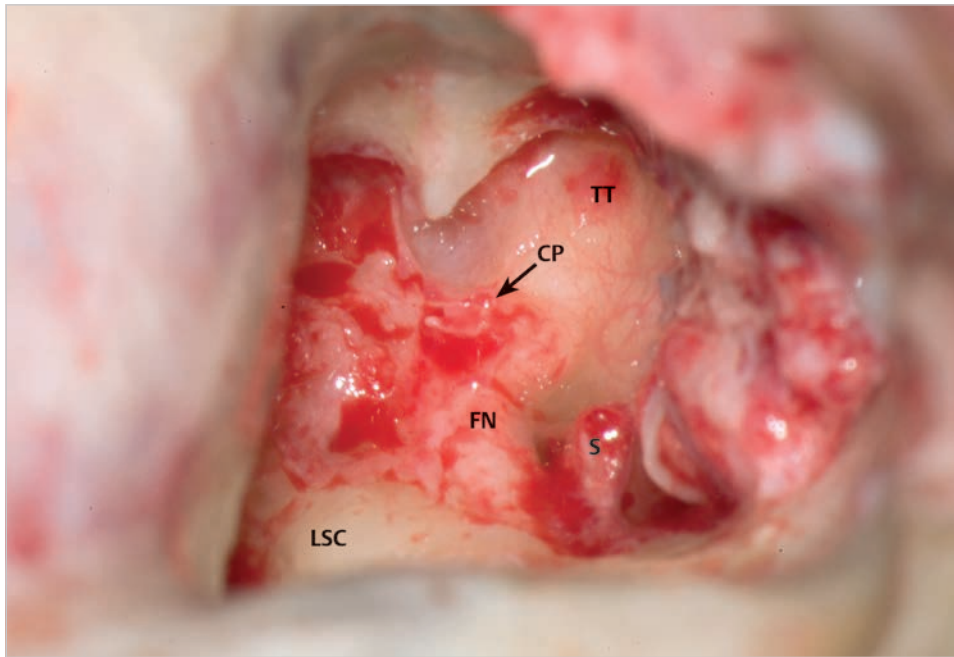


Fig. 7.50 The tendon of the tensor tympani is cut and the anterosuperior part of the fibrous annulus is detached. The tympanic membrane is reflected inferiorly to enhance access to the supratubal recess. The structures around the cochleariform process are shown. In such tight anatomical condition, maximal exposure of structures that gives appropriate orientation is of tremendous importance. CP, cochleariform process; FN, area of facial nerve; LSC, lateral semicircular canal; S, stapes; TT, tensor tympani.



Fig. 7.51 The anterior buttress should be removed to make the cavity rounded.

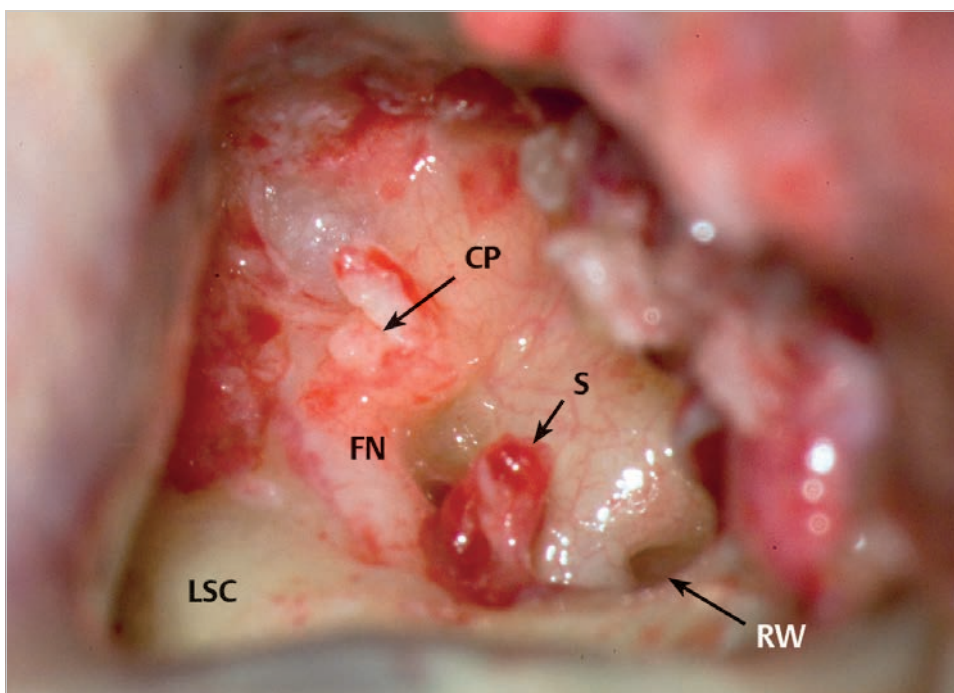


Fig. 7.52 Eradication of cholesteatoma from the middle ear is completed. CP, cochleariform process; FN, facial nerve; LSC, lateral semicircular canal; S, stapes; RW, round window niche.



Fig. 7.53 Meatoplasty is carried out, and conchal cartilage is utilized to obliterate the dips located medially to the sigmoid sinus and the middle fossa plate.



Fig. 7.54 A large piece of temporalis fascia is used to cover the medial wall of the cavity.



Fig. 7.55 The tympanomeatal flap is replaced over the fascia. The handle of the malleus attached to the tympanic membrane is clearly seen (arrow).

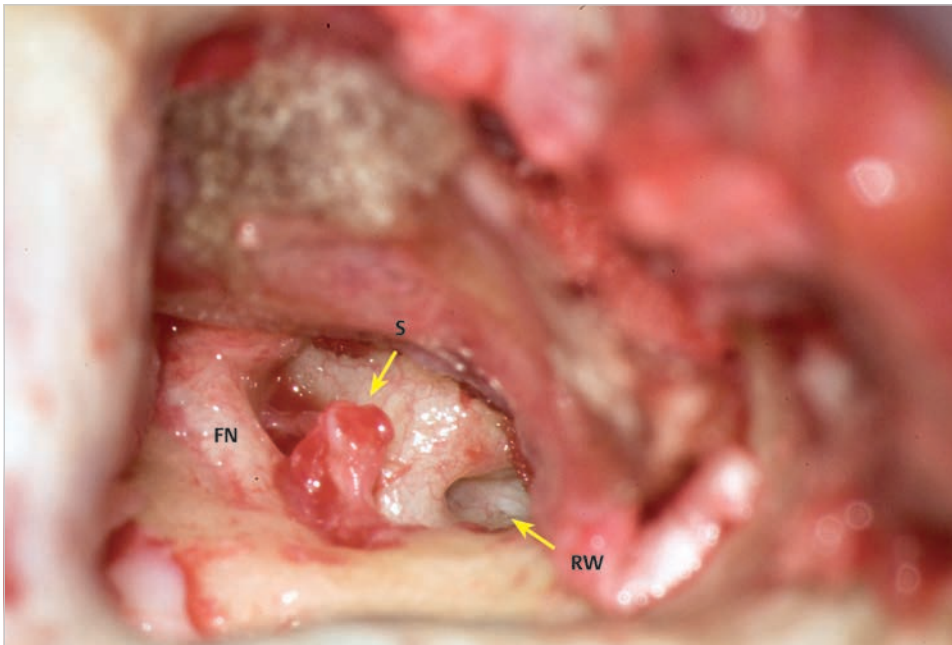


Fig. 7.56 The fascia is reflected anteriorly to visualize the stapes. FN, facial nerve; RW, round window; S, stapes.

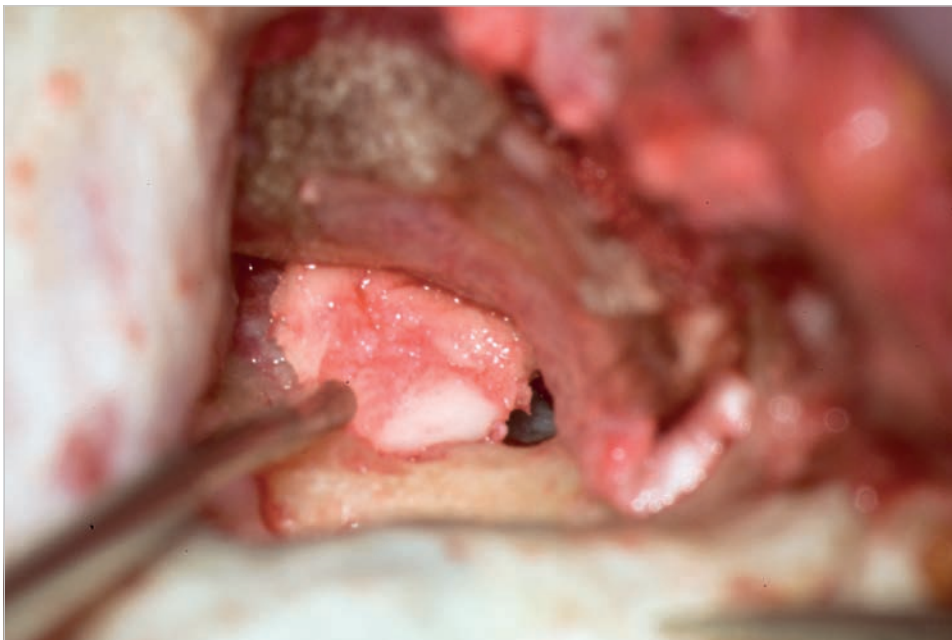


Fig. 7.57 A thick piece of cartilage is placed over the head of the stapes. The tympanic cavity is packed with Gelfoam to support the cartilage and the reconstructed tympanic membrane. After replacing the fascia and the tympanomeatal flap, the cavity is packed with Gelfoam.

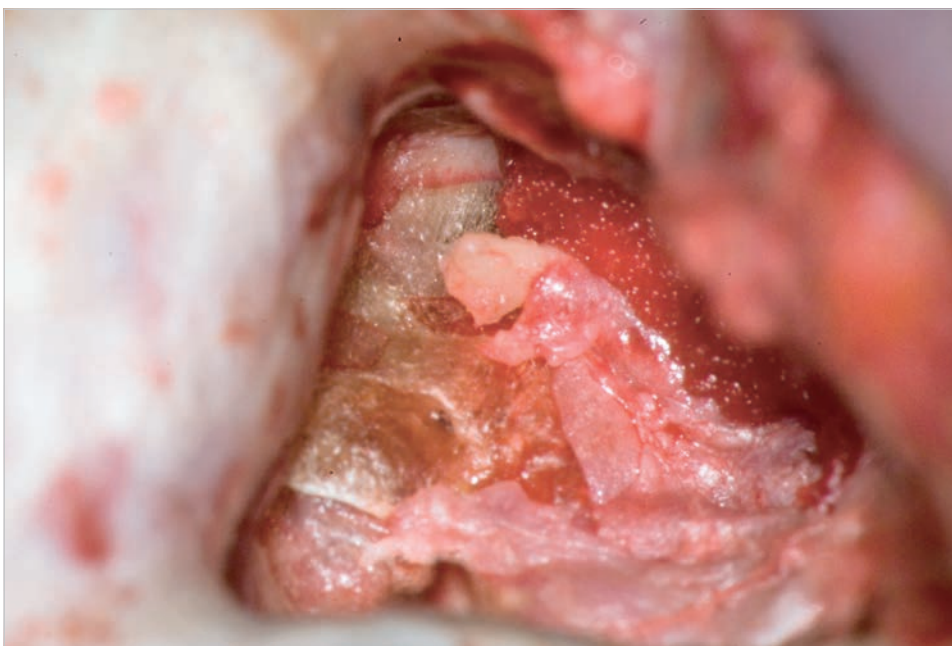


Fig. 7.58 The fascia is replaced, and the cavity is packed with Gelfoam.

Case 7.3 (Left Ear)

See ▶ Fig. 7.59, ▶ Fig. 7.60, ▶ Fig. 7.61, ▶ Fig. 7.62, ▶ Fig. 7.63, ▶ Fig. 7.64, ▶ Fig. 7.65, ▶ Fig. 7.66, ▶ Fig. 7.67, ▶ Fig. 7.68, ▶ Fig. 7.69, ▶ Fig. 7.70, ▶ Fig. 7.71.



Fig. 7.59 The meatus is entered via retroauricular incision. A small erosion is identified in the pars flaccida (arrow).

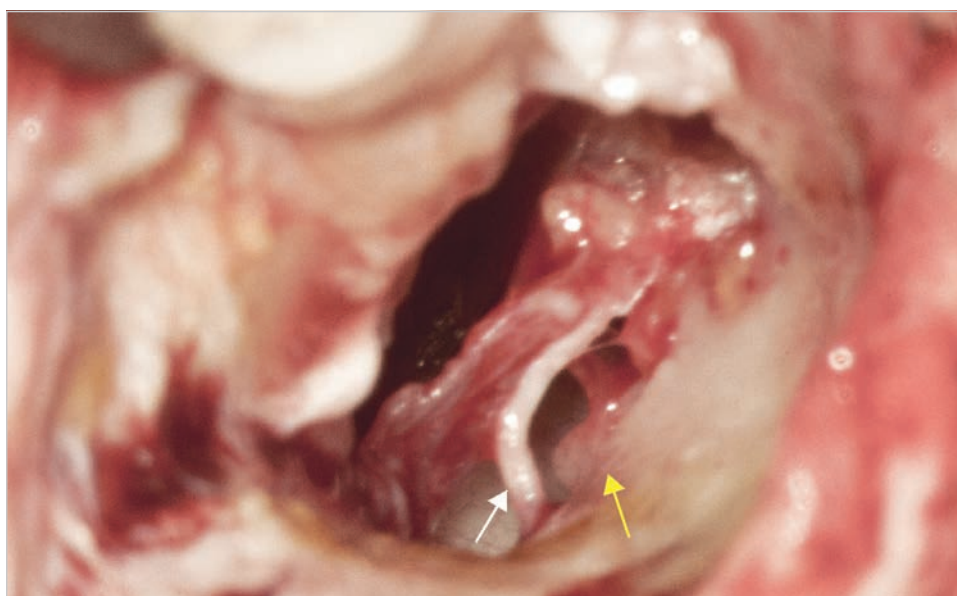


Fig. 7.60 Before starting mastoidectomy, the tympanic cavity is opened to verify absence of cholesteatoma and continuity of the ossicular chain. The chorda tympani nerve (white arrow) and the incudostapedial joint (yellow arrow) are identified.

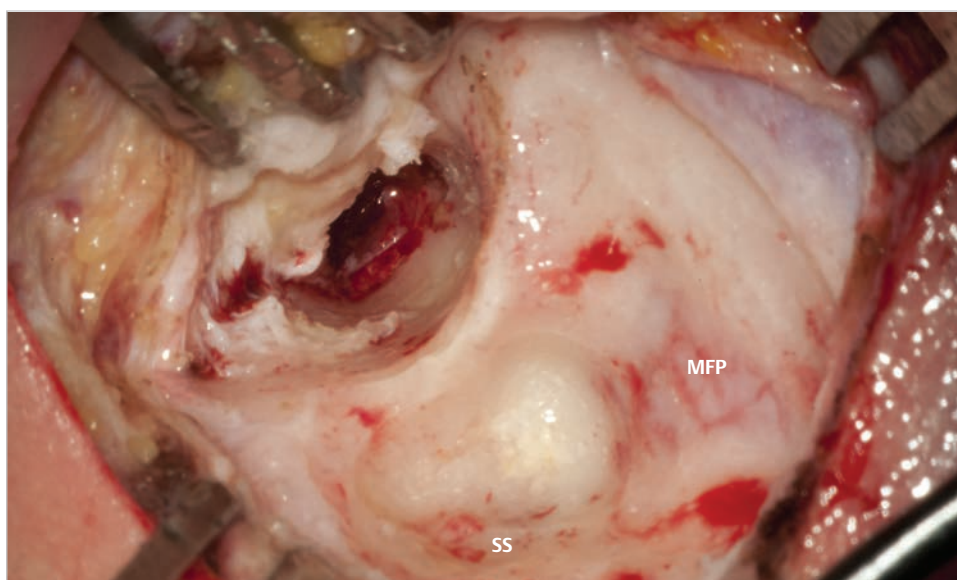


Fig. 7.61 Mastoidectomy is started with canal wall up procedure maintaining the posterior wall of the external auditory canal. The middle fossa plate and the sigmoid sinus are identified superiorly and posteriorly, respectively. Since the temporal bone is compact, no aircell is encountered before reaching the antrum. MFP, middle fossa plate; SS, sigmoid sinus.



Fig. 7.62 Since the antrum in the compact bone is completely filled with cholesteatoma, application of canal wall down procedure is decided. The posterior wall is removed with a large cutting burr.

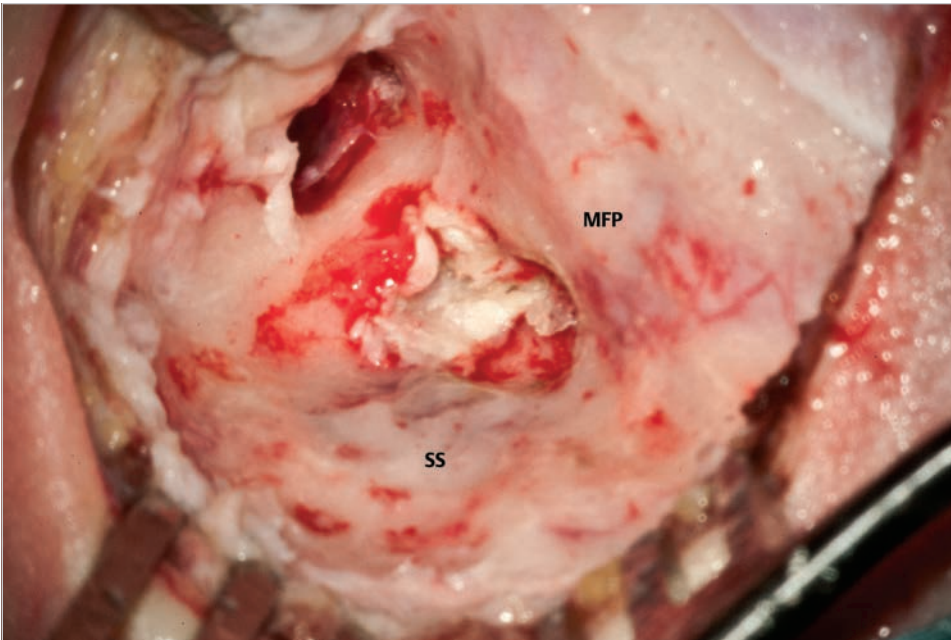


Fig. 7.63 The drilling is advanced from lateral to medial taking care not to make any acute angle in the cavity. MFP, middle fossa plate; SS, sigmoid sinus.

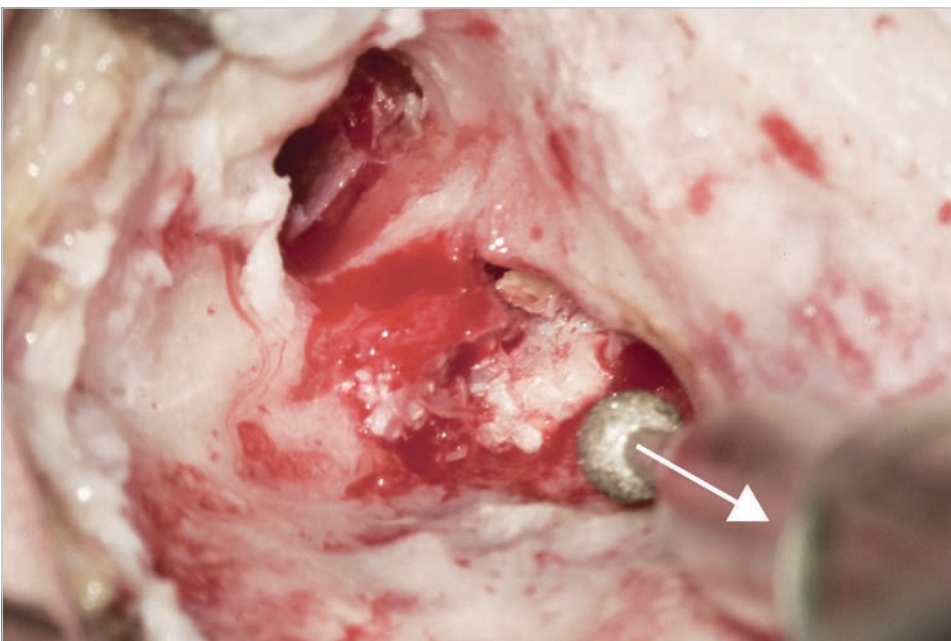


Fig. 7.64 The sinodural angle should be opened widely. The burr should be moved from medial to lateral in this location as demonstrated by the arrow.

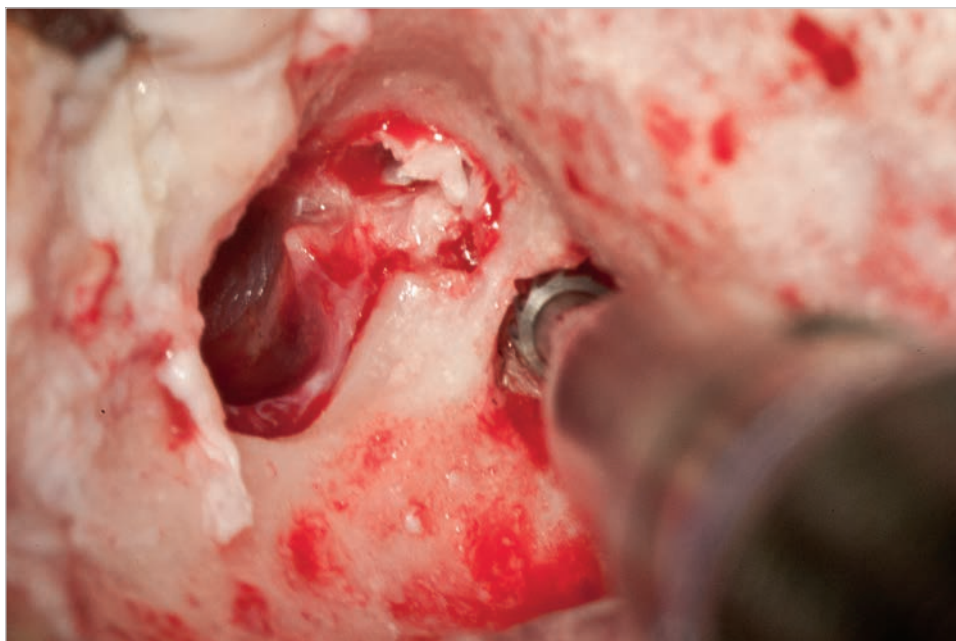


Fig. 7.65 Access to the attic is enlarged with a small cutting burr. Drilling around the attic should be carried out with maximal care, not to touch the ossicular chain.

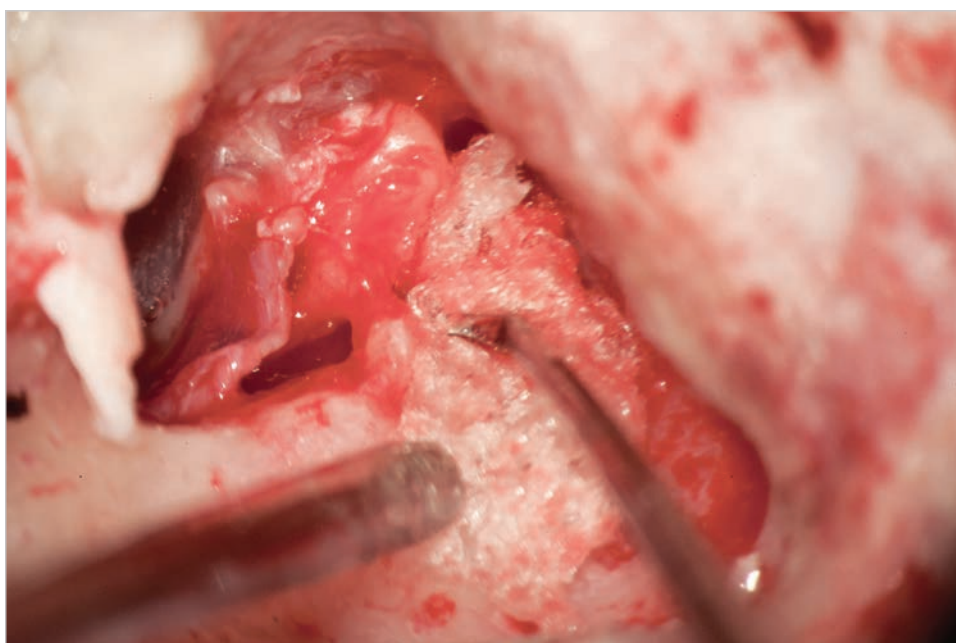


Fig. 7.66 The attic is opened fully, and the majority of cholesteatoma around the chain has already been removed. The incus is heavily eroded. Cottonoid is used to remove matrix behind the chain.



Fig. 7.67 Cholesteatoma located anteriorly to the head of the malleus is started to be dissected.

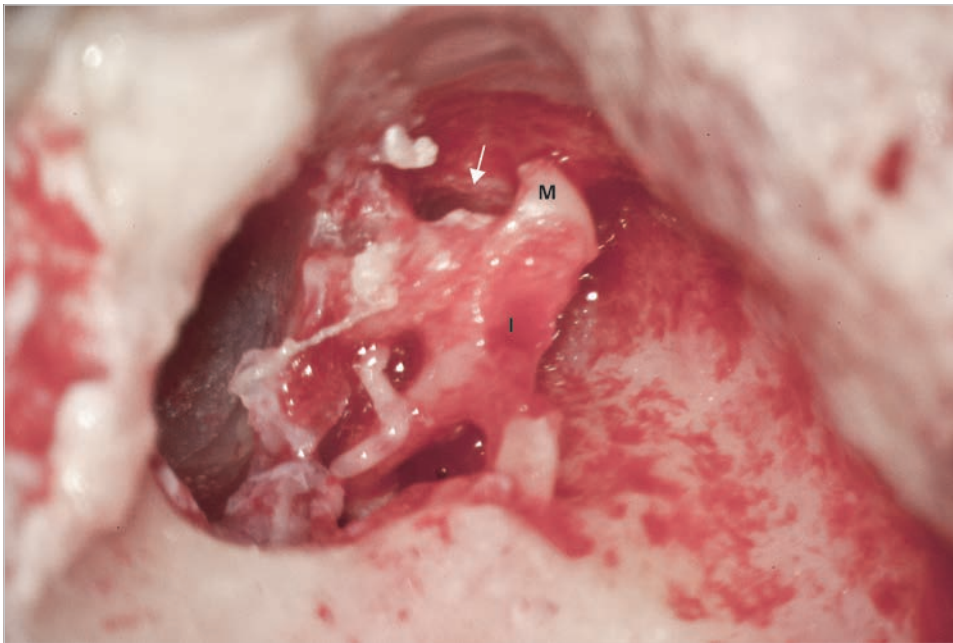


Fig. 7.68 Anteriorly to the heavily eroded head, a deep invagination reaching inaccessible area (*arrow*) is identified. I, incus; M, malleus.

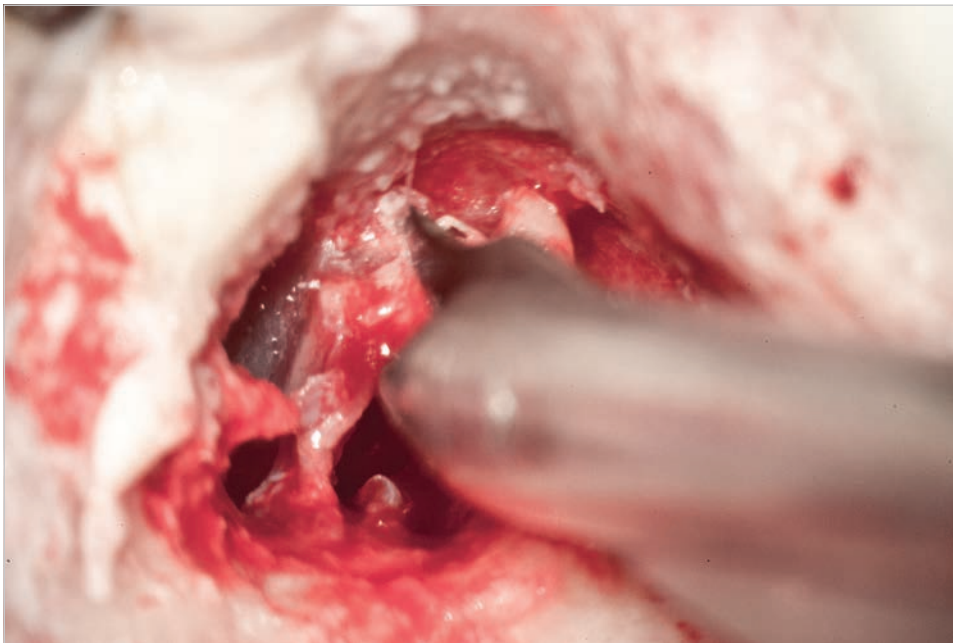


Fig. 7.69 After disarticulating the incudostapedial joint, the incus is removed. The head of the malleus is cut with scissors.



Fig. 7.70 The cholesteatoma is eradicated from the middle ear. The tendon of the tensor tympani muscle is cut to allow anterior reflection of the tympanic membrane. The procedure enlarges access to cholesteatoma invaginating the eustachian tube. ET, eustachian tube; S, stapes.



Fig. 7.71 A piece of cartilage is placed over the stapes. The cartilage serves as a columella and reinforcement material of the tympanic membrane. The cavity is covered with a large piece of temporalis fascia, and the tympanomeatal flap is replaced over it.

Case 7.4 (Right Ear)

See ▶ Fig. 7.72, ▶ Fig. 7.73, ▶ Fig. 7.74, ▶ Fig. 7.75, ▶ Fig. 7.76, ▶ Fig. 7.77, ▶ Fig. 7.78, ▶ Fig. 7.79, ▶ Fig. 7.80, ▶ Fig. 7.81.

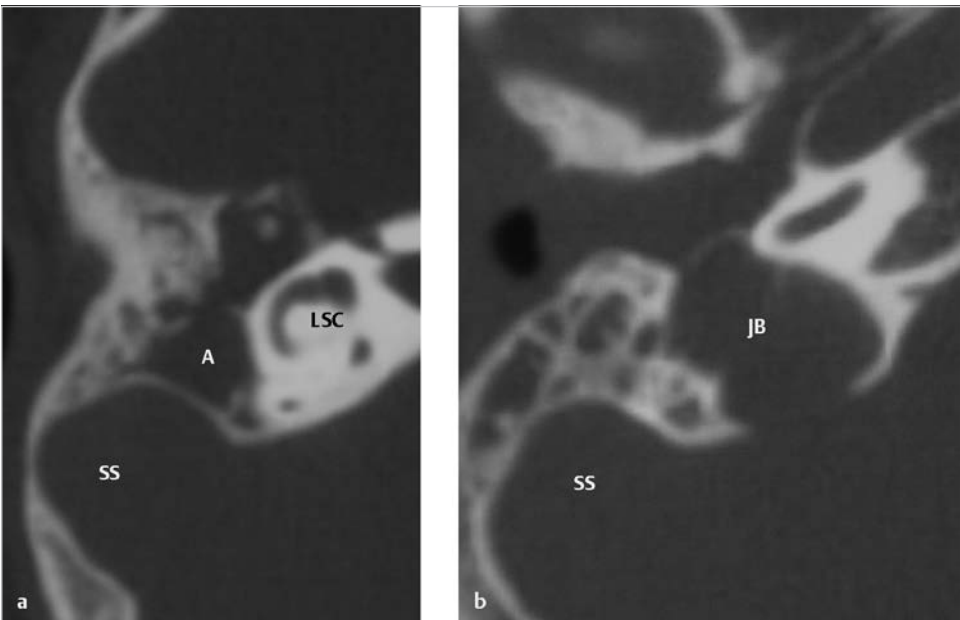


Fig. 7.72 A case of cholesteatoma with prominent sigmoid sinus is shown. (a) The axial CT demonstrated that the protruded sigmoid sinus narrow access to the antrum. (b) The more caudal slice demonstrates a large jugular bulb in the tympanic cavity. A, antrum; JB, jugular bulb; LSC, lateral semicircular canal; SS, sigmoid sinus.

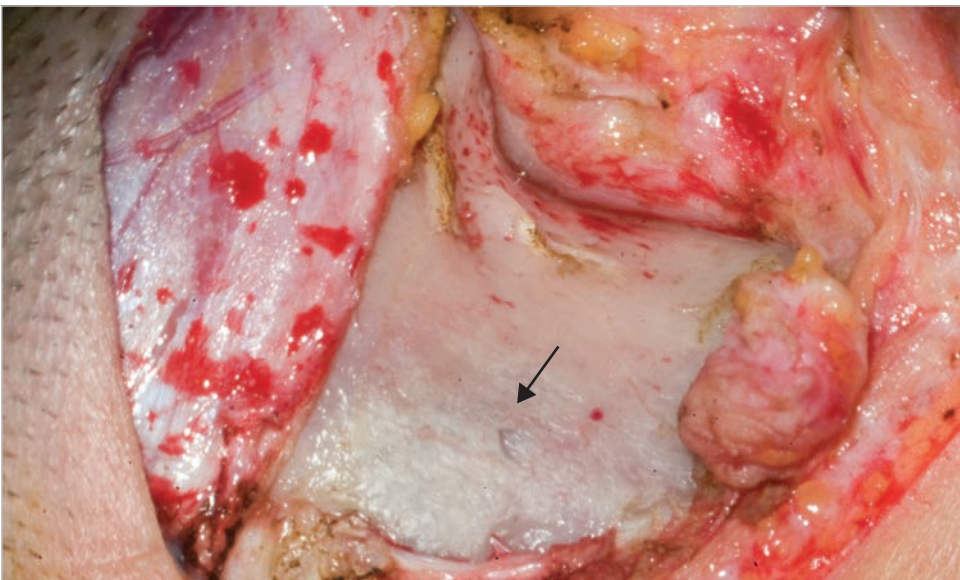


Fig. 7.73 The surface of the mastoid is exposed for mastoidectomy. A bluish area (arrow) occupying posterior half corresponds to the prominent sigmoid sinus.

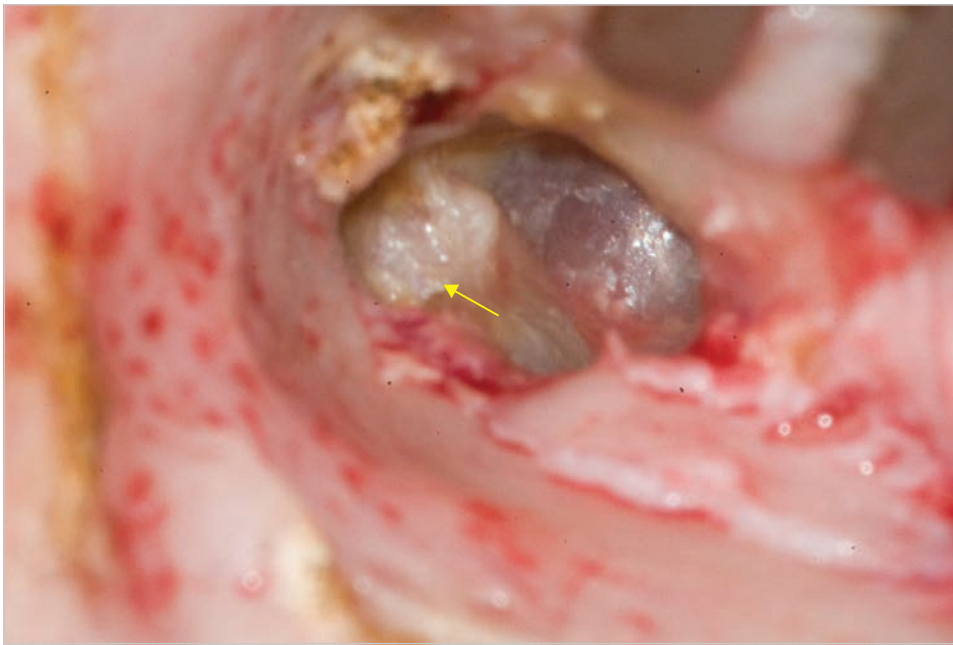


Fig. 7.74 An inflamed entrance of cholesteatoma is located in pars flaccida of the tympanic membrane (arrow).



Fig. 7.75 Canal wall down mastoidectomy is carried out taking care not to expose the protruded sigmoid sinus. To maximize access to the middle ear, the cavity should be saucerized from the beginning by skeletonizing both the middle fossa and the sigmoid sinus without creating sharp bony edges. SS, sigmoid sinus.



Fig. 7.76 The antrum filled with cholesteatoma is opened. Simultaneously, the posterior wall is lowered, and the bony meatus is calibrated. The tympanomeatal flap should be protected by aluminum sheeting. Some meatal skin or cottonoids should be present between the aluminum sheeting and the lateral process of the malleus to prevent sensorineural hearing loss. Ch, cholesteatoma.

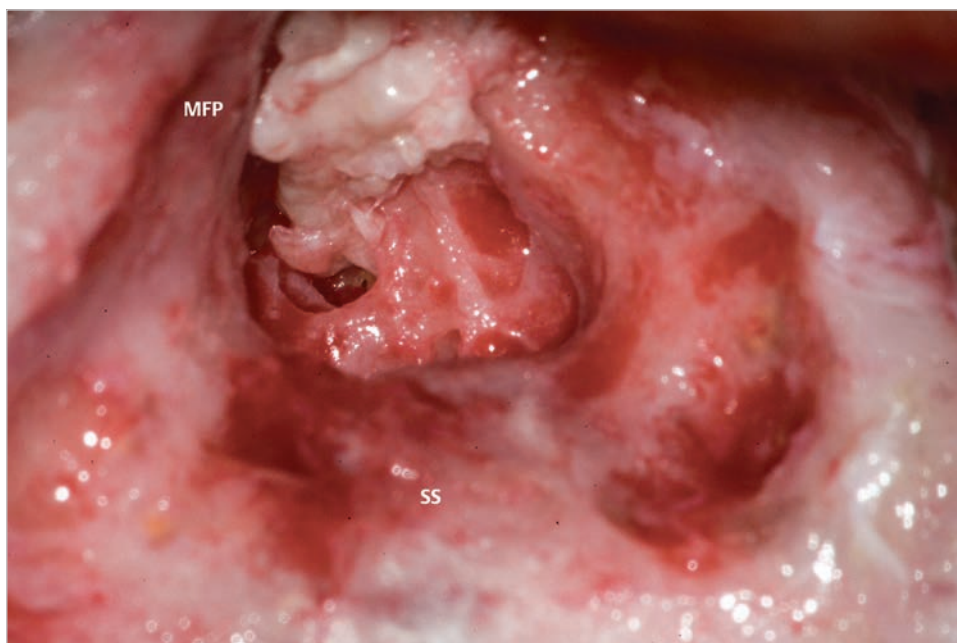


Fig. 7.77 Access to the antrum is enlarged by thinning the bony plate covering the middle fossa and the sigmoid sinus. The perilabyrinthine cells where the matrix is invaginating need to be drilled. MFP, middle fossa plate; SS, sigmoid sinus.

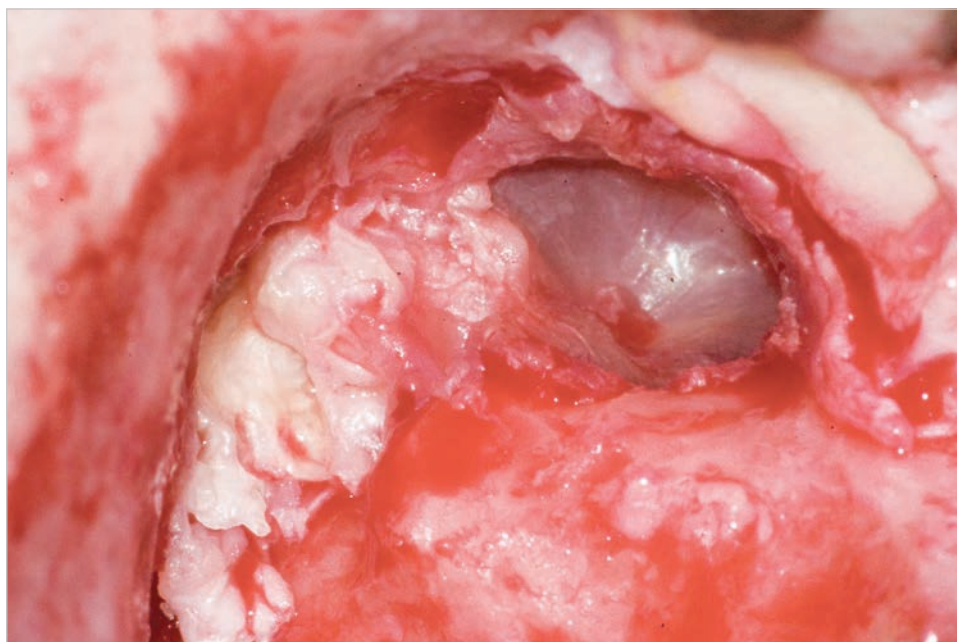


Fig. 7.78 The attic filled with cholesteatoma is shown. The body of the incus is completely eroded.



Fig. 7.79 Exploration of the tympanic cavity revealed limited extension of cholesteatoma in the mesotympanum. A large jugular bulb occupying posteroinferior part of the tympanic cavity is shown (arrow). Note that the top of this jugular bulb is not covered by a bone. CT, chorda tympani.

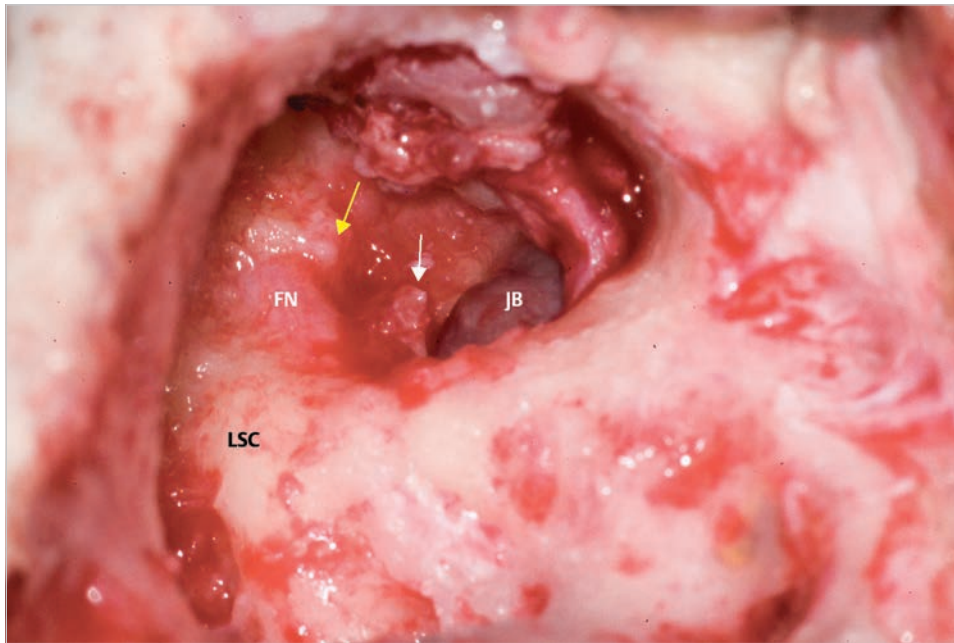


Fig. 7.80 The incus and the head of the malleus are removed and cholesteatoma is eradicated from the middle. The tympanic segment of the facial nerve is exposed just posteriorly to the cochleariform process (*yellow arrow*). Very large jugular bulb almost touching to the stapes (*white arrow*) is seen. FN, facial nerve; JB, jugular bulb; LSC, lateral semicircular canal.

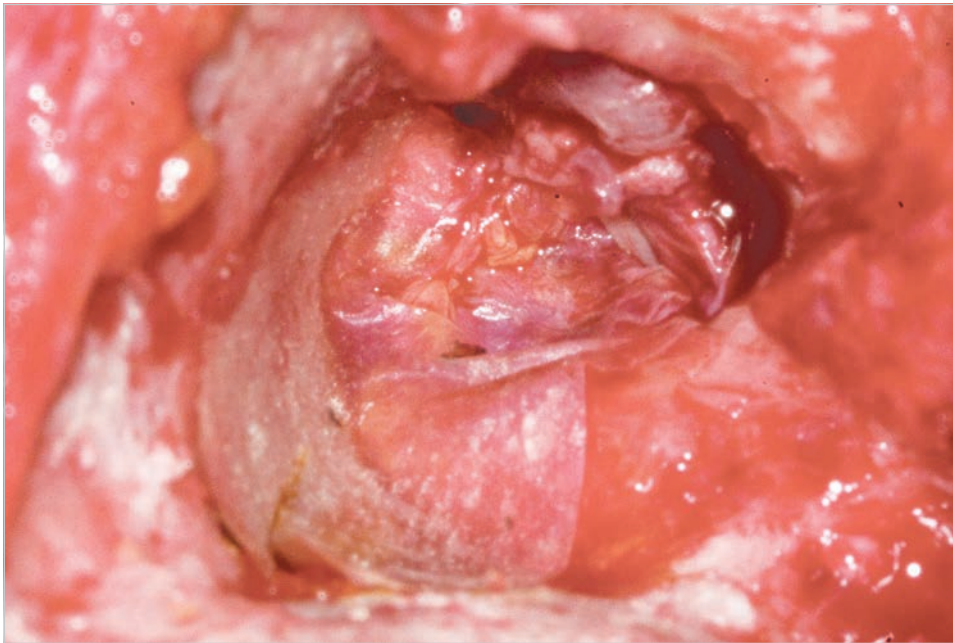


Fig. 7.81 The tympanic cavity is packed with Gelfoam, and a large piece of cartilage is placed over the stapes. A fascia is grafted underlay to reconstruct the tympanic membrane and to cover the medial wall of the mastoid.

7.1.3 Staged Surgery in Canal Wall Down Tympanoplasty

In many cases of cholesteatoma, the tympanic cavity is involved and the tympanic membrane is retracted. The tympanic cavity may get scar or granulation tissue, or the tympanic membrane may be adherent to the medial wall. Closure of perforations may be required. In such situation, unpredictable factors such as res-carring of the tympanic cavity, adhesion of the reconstructed tympanic membrane, and displacement of the columella due to postoperative migration of the tympanic membrane may

interfere postoperative sound transmission. To obtain more stable result, the surgery is often staged, and the ossicular chain is reconstructed in the second stage. In addition, residual disease, if any, can be removed and retraction pocket may be corrected in the second stage, to enhance curability of the entire surgery.

Case 7.5 (Left Ear)

See ▶ Fig. 7.82, ▶ Fig. 7.83, ▶ Fig. 7.84, ▶ Fig. 7.85, ▶ Fig. 7.86, ▶ Fig. 7.87, ▶ Fig. 7.88, ▶ Fig. 7.89, ▶ Fig. 7.90, ▶ Fig. 7.91, ▶ Fig. 7.92, ▶ Fig. 7.93, ▶ Fig. 7.94, ▶ Fig. 7.95.

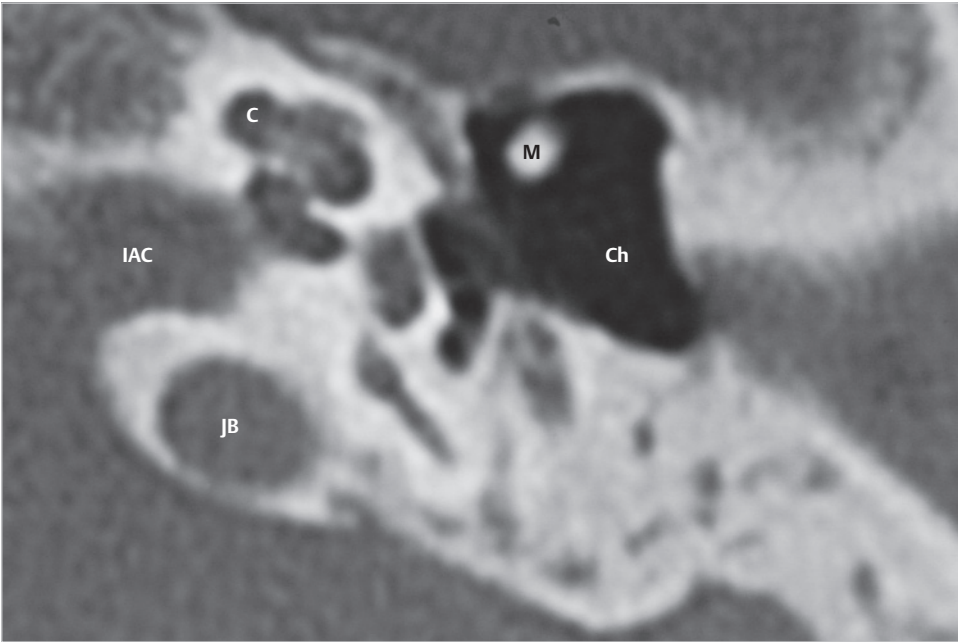


Fig. 7.82 A case of cholesteatoma in contracted mastoid. The CT demonstrates large erosion in the attic. The head of the malleus can be seen in the attic, but the incus and the superstructure of the stapes are absent. C, cochlea; Ch, cholesteatoma; IAC, internal auditory canal; JB, jugular bulb; M, malleus.

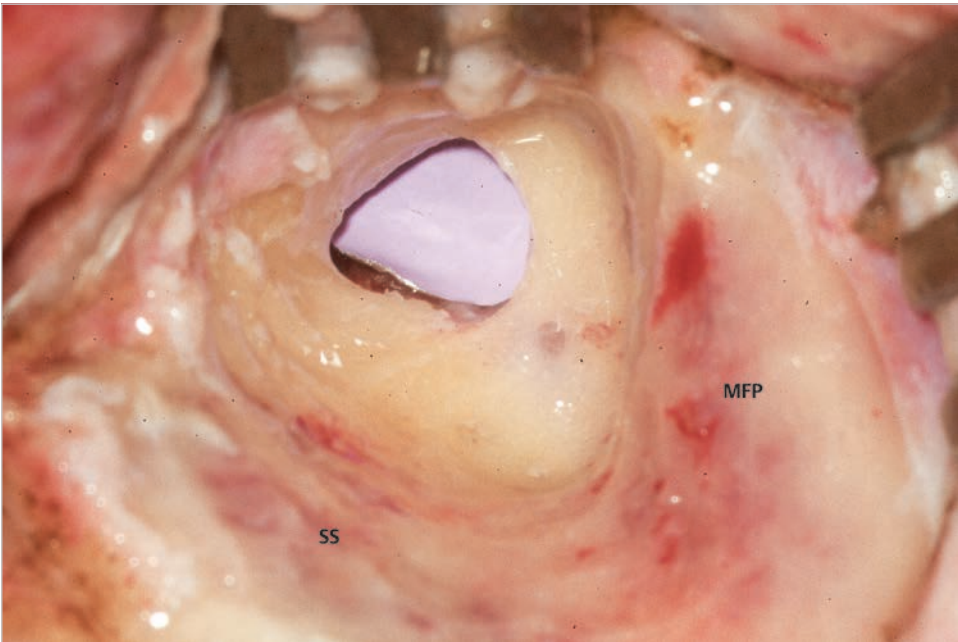


Fig. 7.83 The middle fossa plate and the sigmoid sinus are identified superiorly and posteriorly, respectively. The tympanomeatal flap is protected with an aluminum sheeting. Note that the cavity is well saucerized. The anterior meatal wall is also calibrated. MFP, middle fossa plate; SS, sigmoid sinus.



Fig. 7.84 Drilling is advanced medially to reach the small antrum filled with cholesteatoma. Note that development of aircell system in the mastoid is very poor, and the small antrum is surrounded by compact bone.

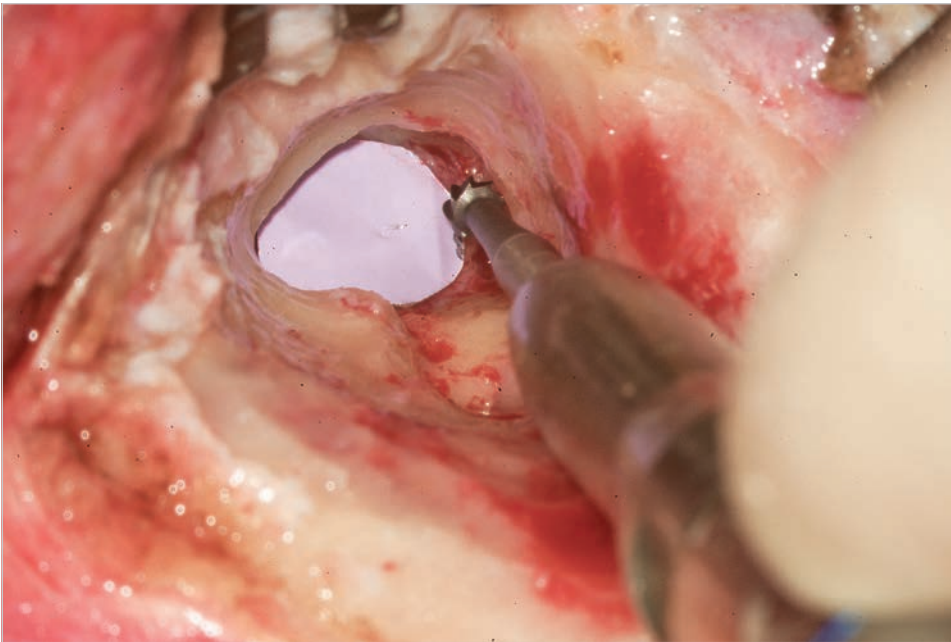


Fig. 7.85 All sharp bony edges in the cavity should be removed to make the cavity rounded. The tympanomeatal flap is protected with a piece of aluminum sheet.

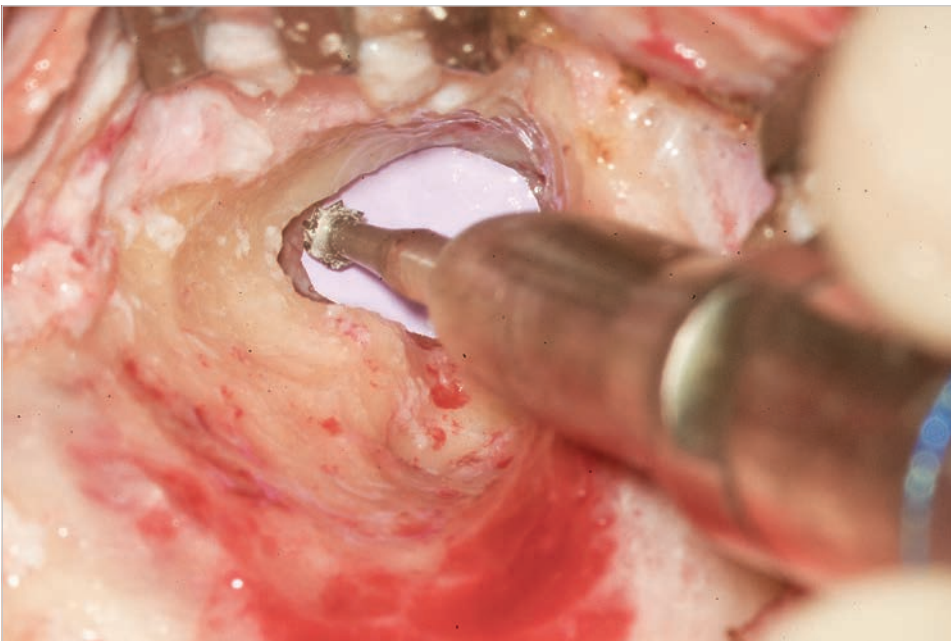


Fig. 7.86 To facilitate postoperative care and second-stage surgery, the anterior and the inferior meatal walls should also be calibrated.

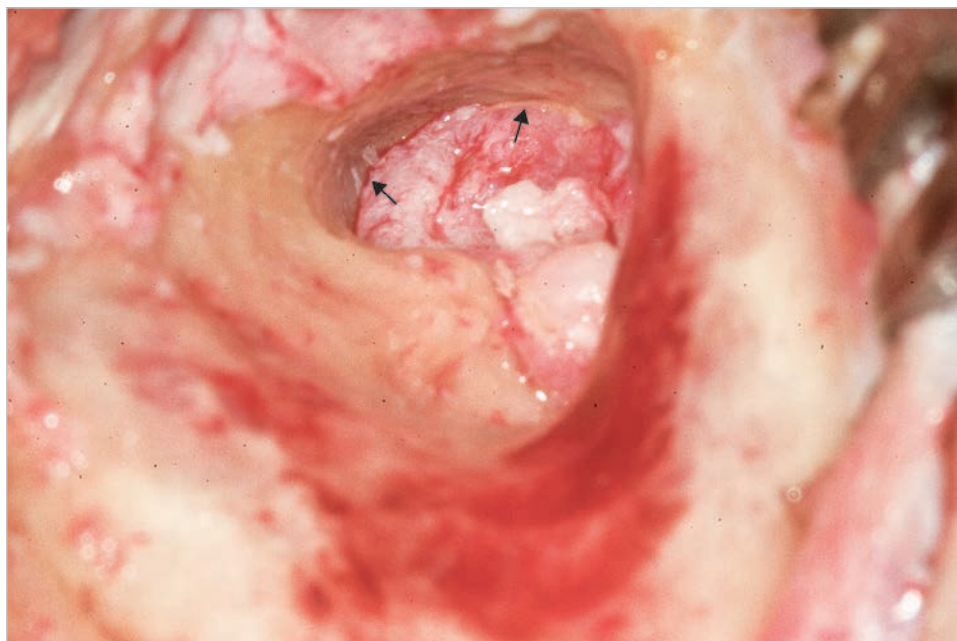


Fig. 7.87 The calibration of the meatal wall should be carried out to such extent that the entire annulus (*arrows*) can be seen without moving microscope.

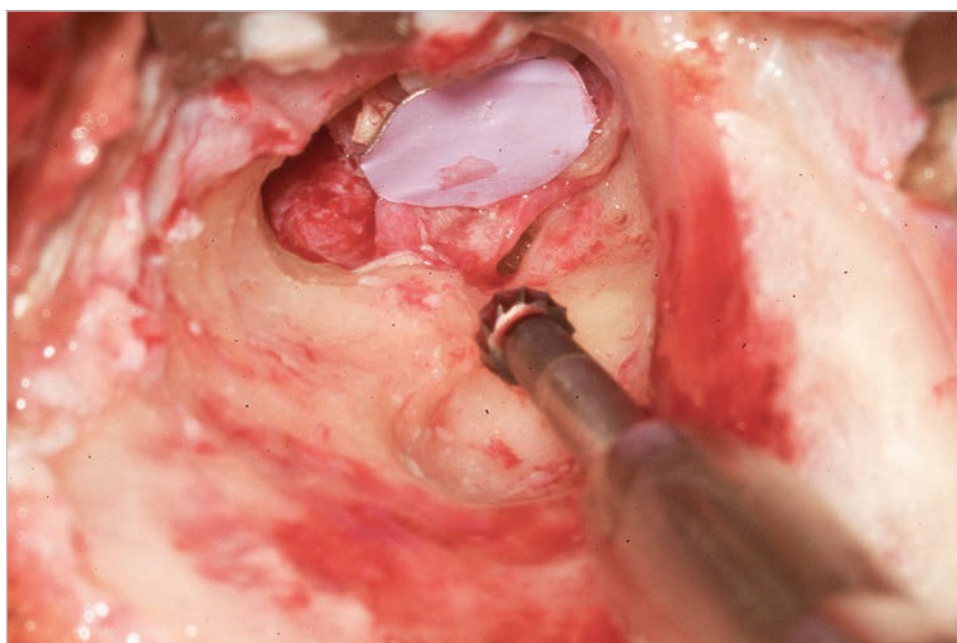


Fig. 7.88 The facial ridge is further lowered with a small cutting burr, and saucerization of the cavity is completed.

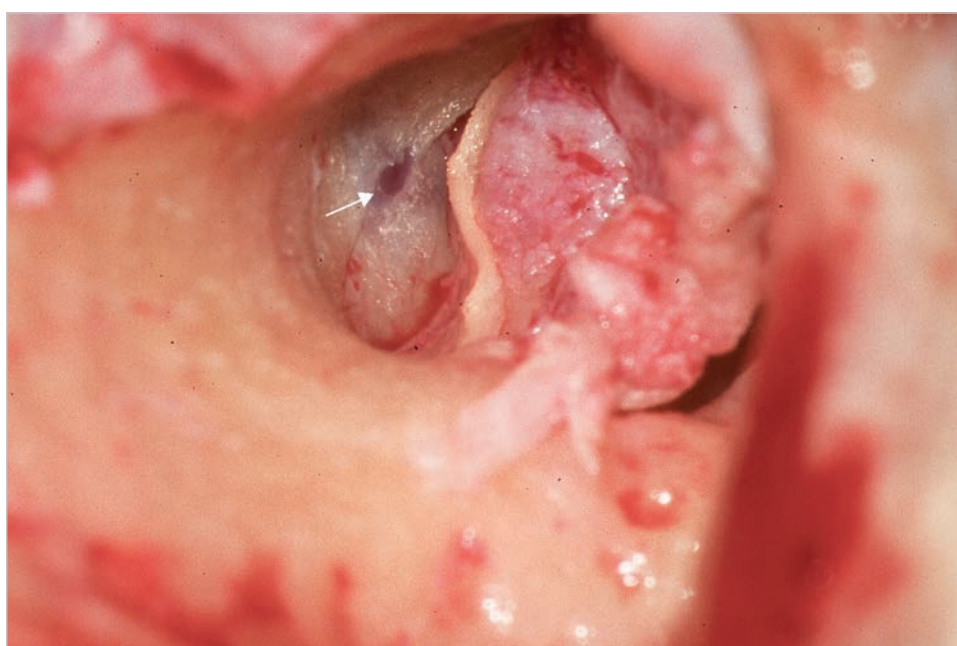


Fig. 7.89 The fibrous annulus is detached from inferior. Note that the anteriorly located very large jugular bulb forms the inferior wall of the tympanic cavity, and small part of it is exposed in the bony annulus (*arrow*). In such situation, inattentive dissection of the fibrous annulus may damage the bulb, and considerable bleeding may occur. Application of Surgicel over the small hole eventually stops such bleeding.

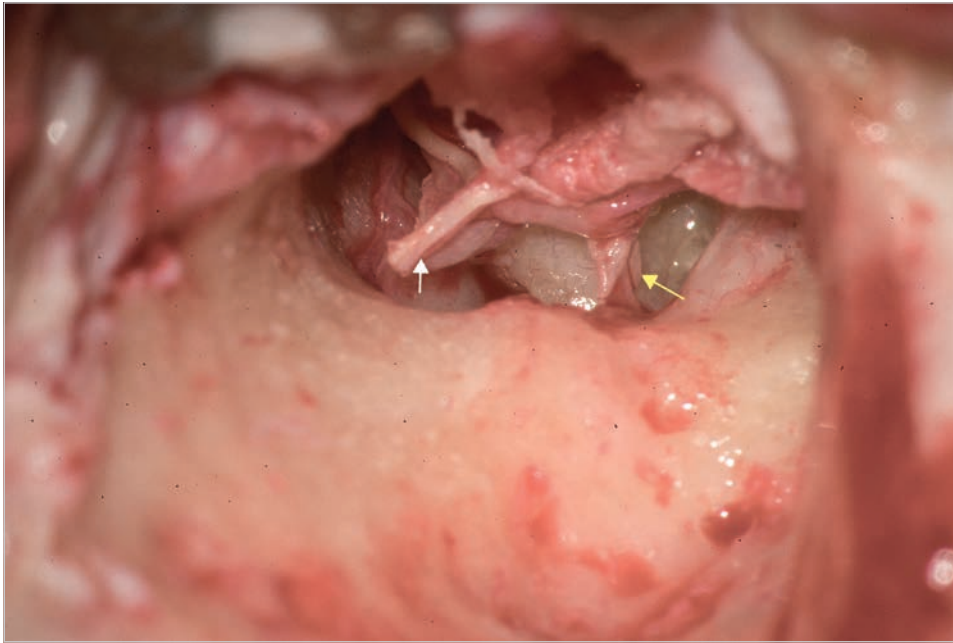


Fig. 7.90 Dissection of the fibrous annulus is advanced superiorly taking care not to leave cholesteatoma matrix covering the posterior wall of the tympanic cavity. The incus is completely eroded, and the superstructures of the stapes are completely eroded. The chorda tympani nerve (white arrow) and the footplate of the stapes (yellow arrow) can be seen.

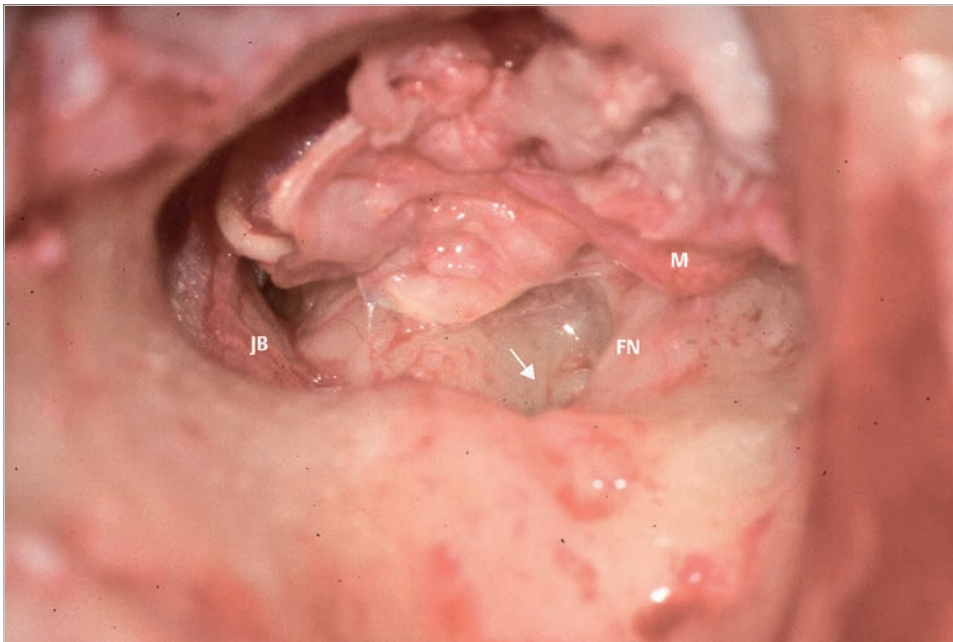


Fig. 7.91 Dissection of the fibrous annulus is advanced superiorly taking care not to leave cholesteatoma matrix covering the posterior wall of the tympanic cavity. The incus is completely eroded, and the superstructures of the stapes are completely eroded. The chorda tympani nerve is sacrificed. The footplate of the stapes (arrow) can be seen inferiorly to the exposed facial nerve. FN, facial nerve; JB, jugular bulb; M, head of malleus.

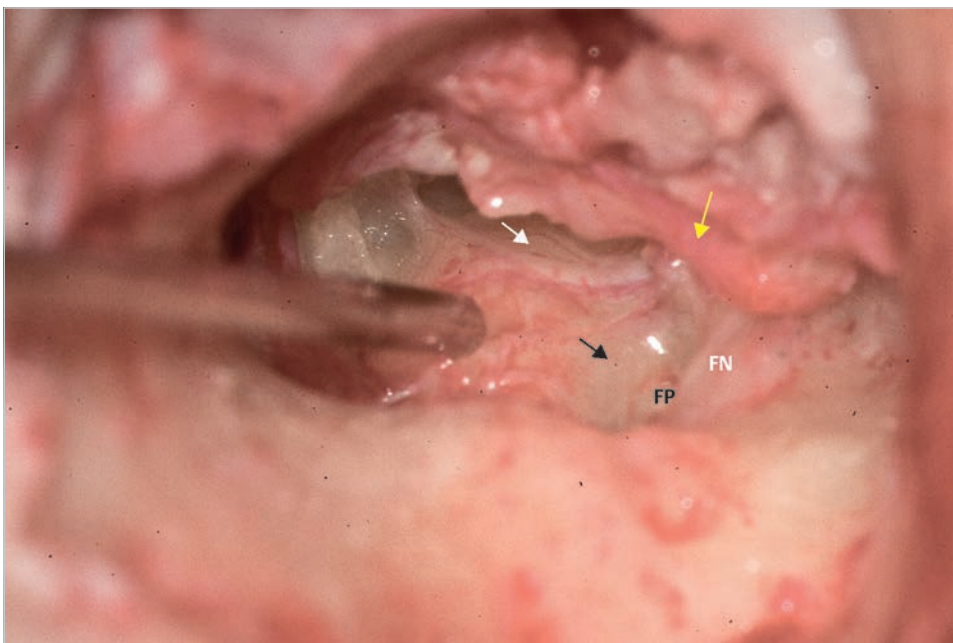


Fig. 7.92 In higher magnification, the Jacobson's nerve running over the promontory is seen (white arrow). The cochleariform process (yellow arrow) forms the anterosuperior rim of the oval window niche (black arrow), and the facial nerve courses just superomedial to it. FN, facial nerve; FP, footplate.

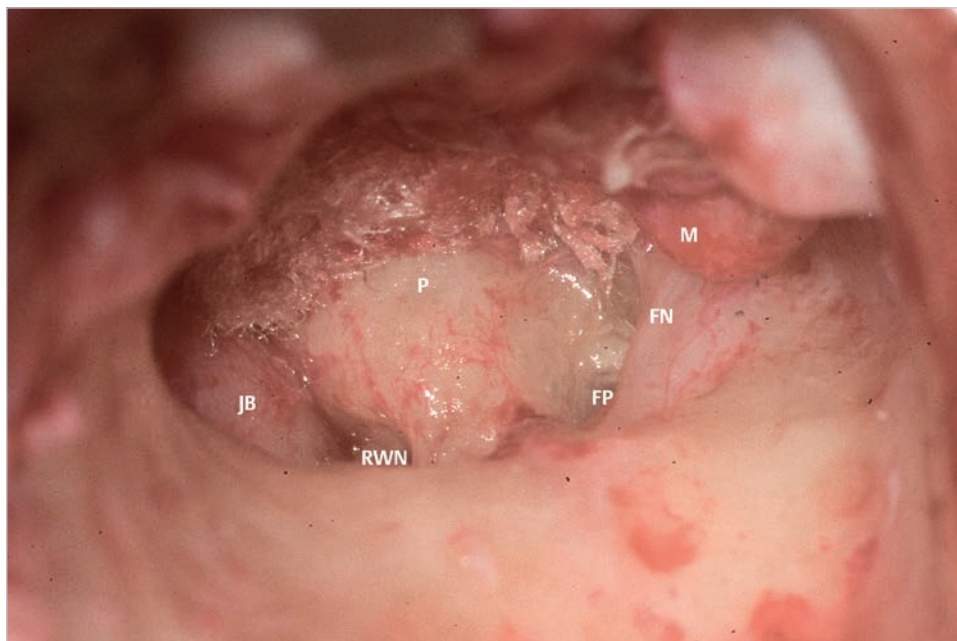


Fig. 7.93 Closer view of structures in the posterior mesotympanum. FN, facial nerve; FP, footplate; JB, jugular bulb; M, head of malleus; P, promontory; RWN, round window niche.



Fig. 7.94 A small piece of Silastic sheeting is placed in the tympanic cavity.



Fig. 7.95 A large piece of temporalis fascia is used to reconstruct the tympanic membrane and to cover the medial wall of the cavity which is partially obliterated with pieces of conchal cartilage and bone paste. The tympanomeatal flap with malleus is replaced over the fascia, and the cavity is packed with pieces of Gelfoam.

Second Stage of This Case

See ►Fig. 7.96, ►Fig. 7.97, ►Fig. 7.98, ►Fig. 7.99, ►Fig. 7.100,
►Fig. 7.101, ►Fig. 7.102, ►Fig. 7.103.



Fig. 7.96 Second-stage surgery of the same case. The cavity is well epithelized. The malleus left in the first stage can be identified (*arrow*). Note that the tympanic membrane is easily accessible as a result of sufficient bone work in the inferior and anterior bony meatus in the first-stage surgery.



Fig. 7.97 A U-shaped incision is made from the anterior wall to the posterior wall to open the tympanic cavity from inferior. A small piece of cottonoid is used to dissect the meatal skin so as not to damage it and also to control hemorrhage.



Fig. 7.98 The tympanic cavity is opened from inferior to sufficiently expose the area of the footplate. Silastic sheeting placed in the first stage is seen.

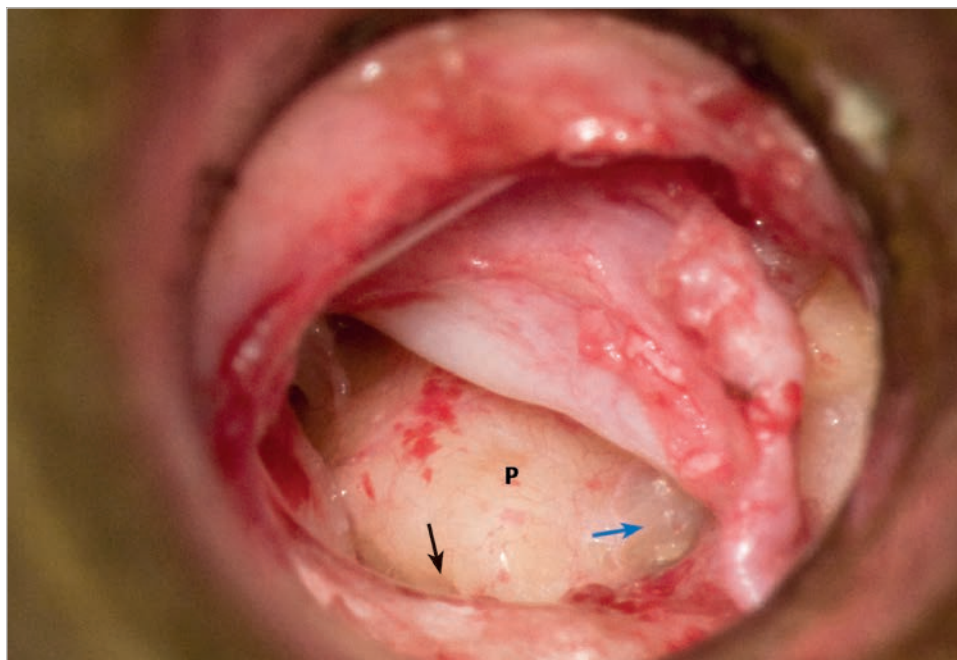


Fig. 7.99 The tympanic cavity is opened from inferior to sufficiently expose the area of the footplate, and the Silastic sheeting is removed. The promontory (P) is located between the round window niche (*black arrow*) and the oval window covered with mucosal fold (*blue arrow*).

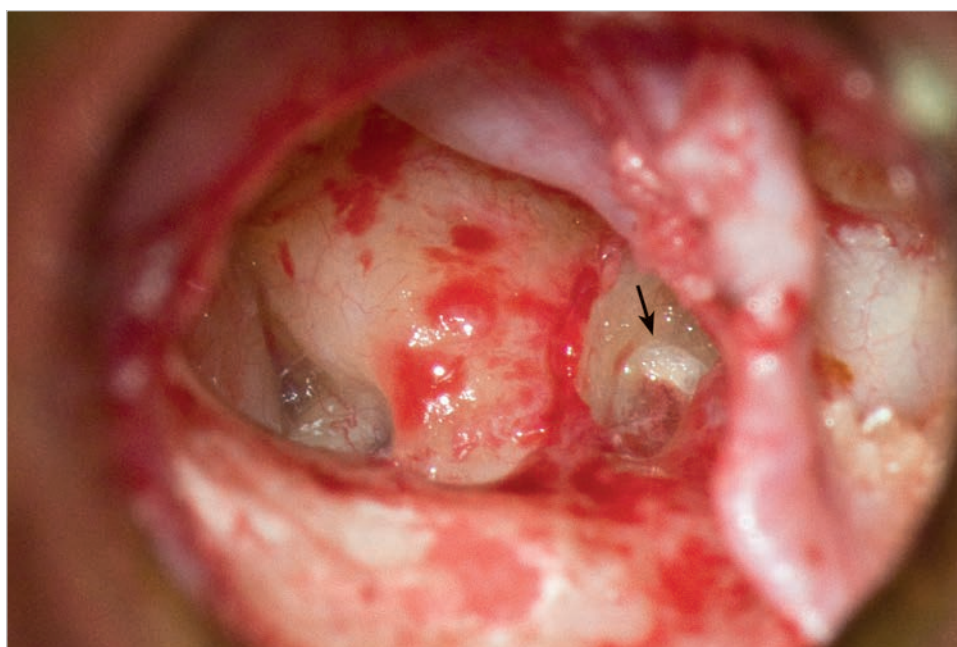


Fig. 7.100 The mucosal fold covering the footplate is removed. The remnant of the anterior crus is seen (*arrow*).



Fig. 7.101 The tympanic cavity is partially packed with pieces of Gelfoam. The area of the footplate is left unpacked for following ossiculoplasty.



Fig. 7.102 The incus is molded to fit the distance between the tympanic membrane and the footplate.

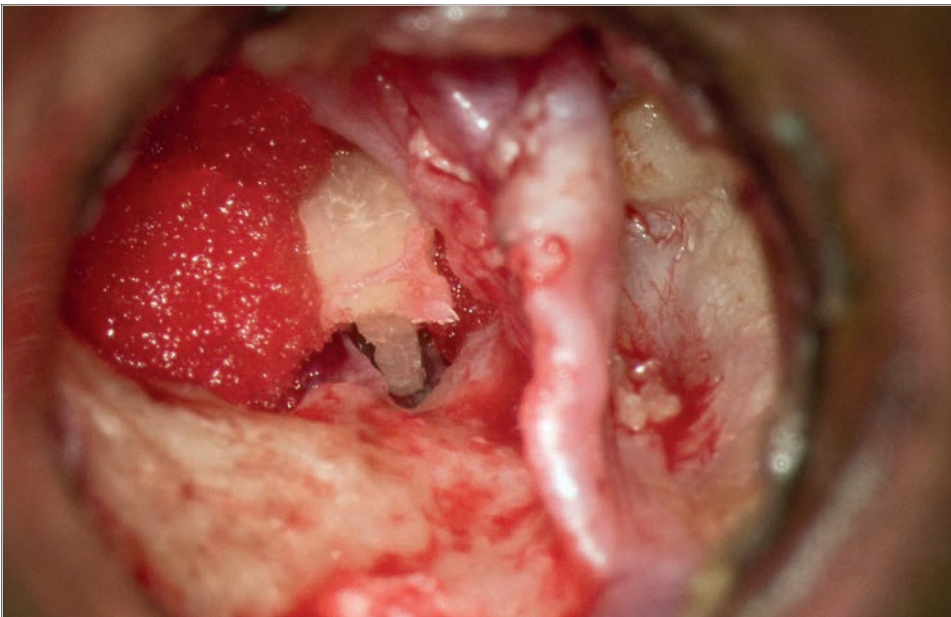


Fig. 7.103 The molded incus is in position. The columella is supported with pieces of Gelfoam to avoid adhesion to the promontory located inferiorly and to the facial nerve located superiorly. To ensure appropriate alignment of the columella over the footplate, the area posterior to the columella is left unpacked at this moment. The space should be packed later to avoid adhesion of the columella to the posterior wall. The cavity will be closed by replacing the tympanomeatal flap.

Case 7.6 (Right Ear)

See ► Fig. 7.104, ► Fig. 7.105, ► Fig. 7.106, ► Fig. 7.107, ► Fig. 7.108, ► Fig. 7.109, ► Fig. 7.110, ► Fig. 7.111, ► Fig. 7.112, ► Fig. 7.113, ► Fig. 7.114, ► Fig. 7.115, ► Fig. 7.116, ► Fig. 7.117, ► Fig. 7.118, ► Fig. 7.119.

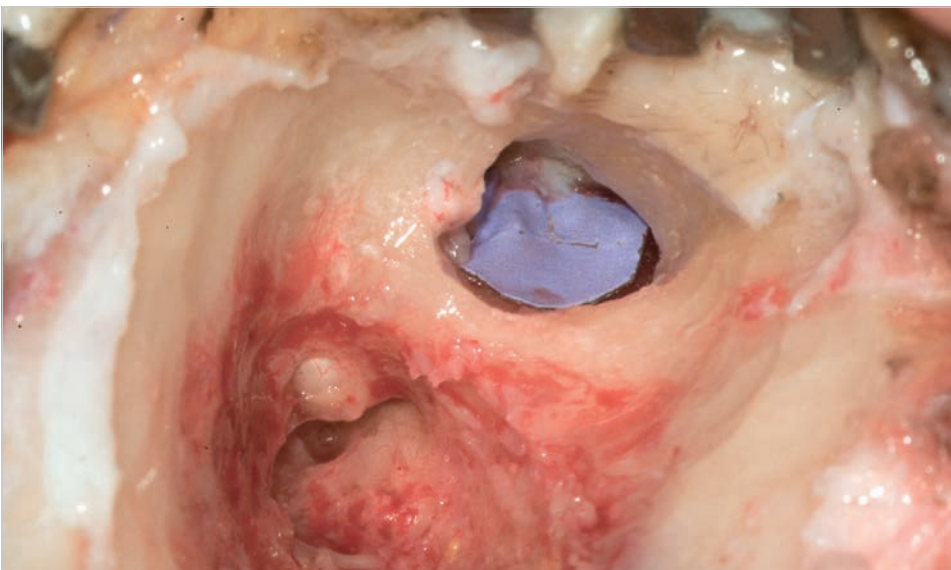


Fig. 7.104 Canal wall down mastoidectomy is carried out. The posterior end of cholesteatoma reaching the antrum is beginning to be seen. The tympanomeatal flap is detached from the bony meatus and protected with aluminum sheeting for canaloplasty.

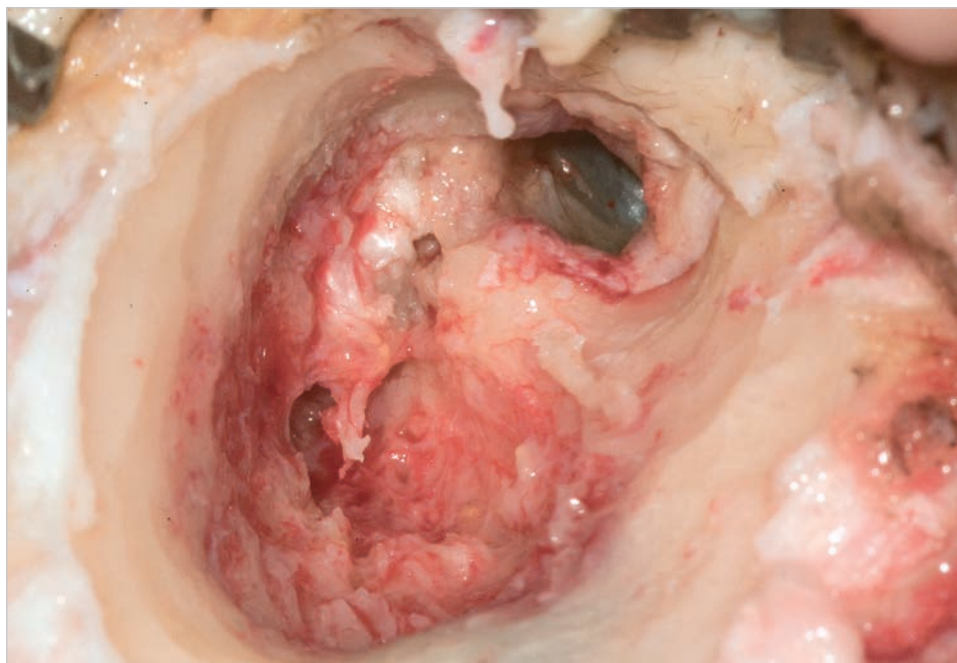


Fig. 7.105 The canaloplasty is completed, and the scutum is removed with a curette after thinning the bony bridge lateral to the chain. The cholesteatoma in the attic is visualized.

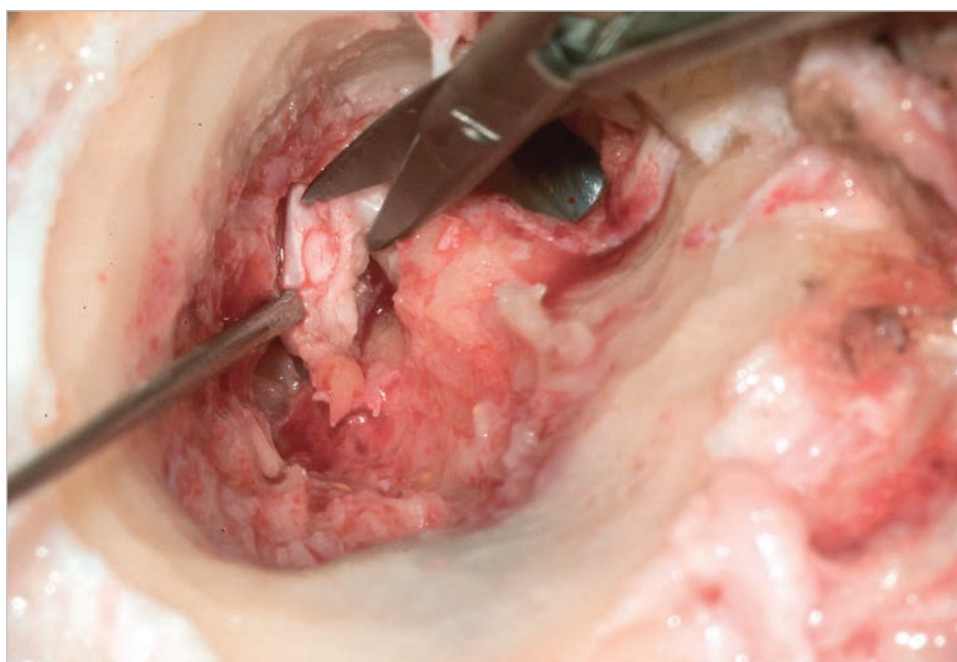


Fig. 7.106 Debulking and piecemeal removal of cholesteatoma is of importance to visualize structures around the matrix, and to make room for dissection.

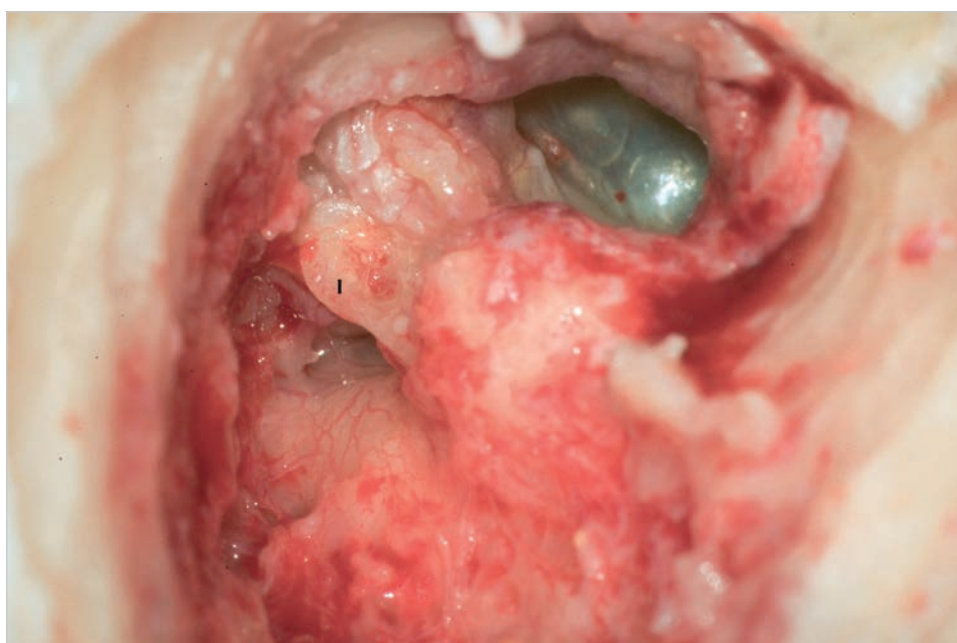


Fig. 7.107 Continuity of the ossicular chain is not compromised by the cholesteatoma. The tympanic membrane remains intact. Modified Bondy technique to preserve continuity of the chain may be indicated in this situation. I, incus.

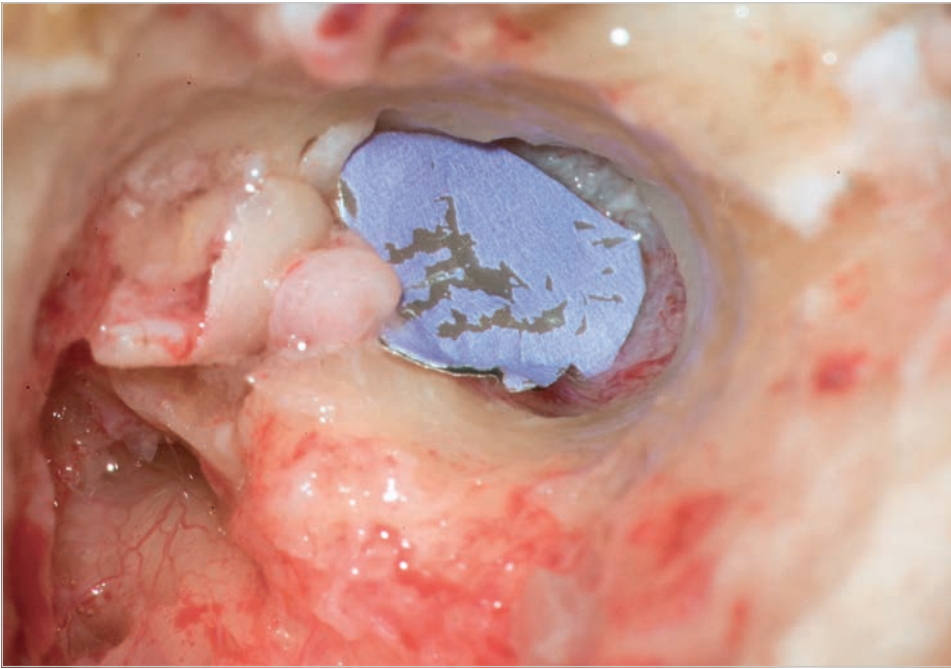


Fig. 7.108 The facial ridge is further lowered to the level of the tympanic membrane to obtain good rounded cavity. The tympanomeatal flap should be protected by aluminum sheeting during drilling.

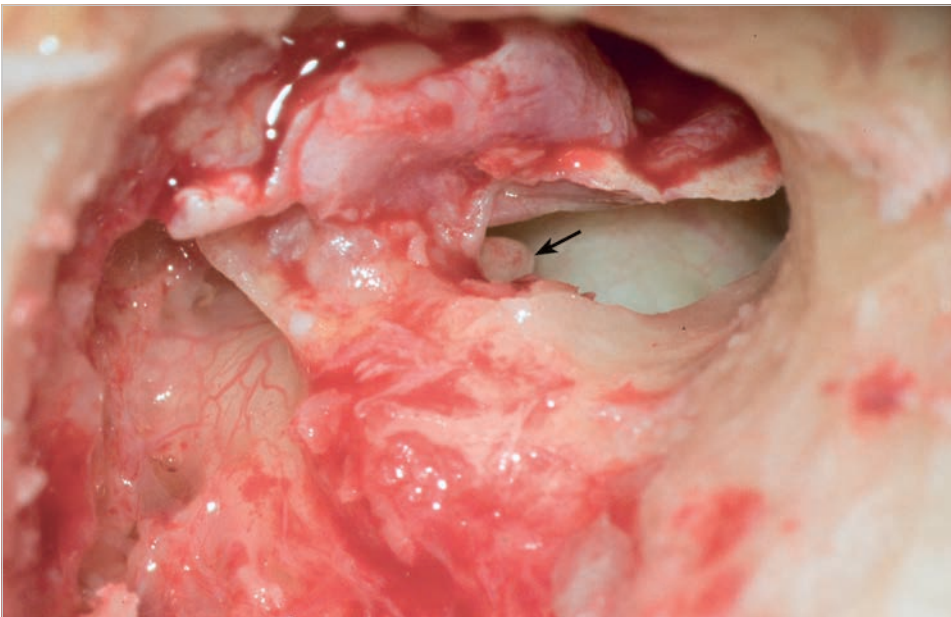


Fig. 7.109 The fibrous annulus is detached to verify absence of cholesteatoma in the tympanic cavity. The long process of the incus is seen (*arrow*).



Fig. 7.110 The cholesteatoma is detached from the incus. The lateral face of the incus is considerably eroded, but continuity of the ossicular chain is retained.

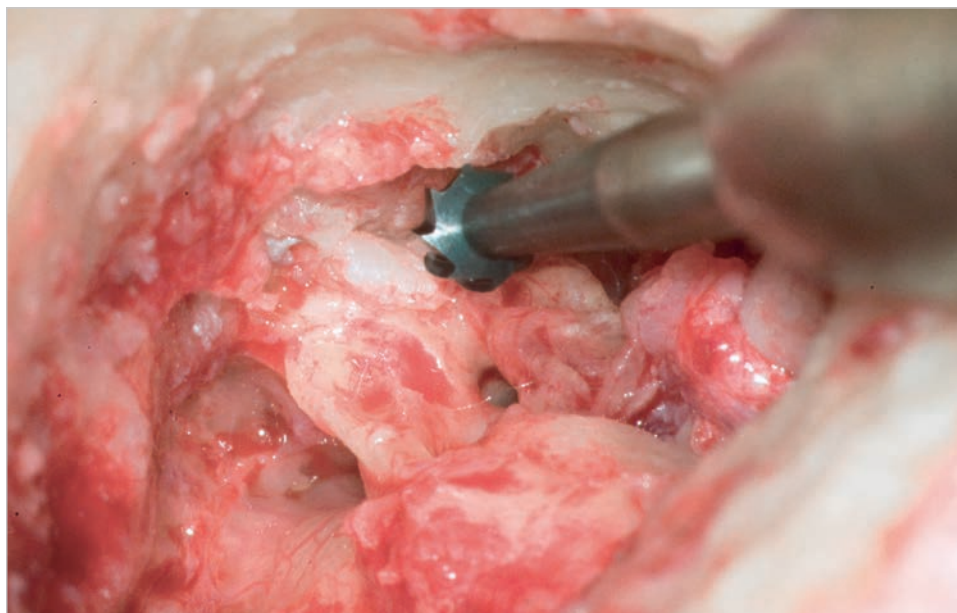


Fig. 7.111 Bony overhangs are removed with a cutting burr to expose the cholesteatoma extending anteriorly. To avoid contact to the ossicular chain, the drill should be moved either from the area near the chain to elsewhere, or parallel to the chain.

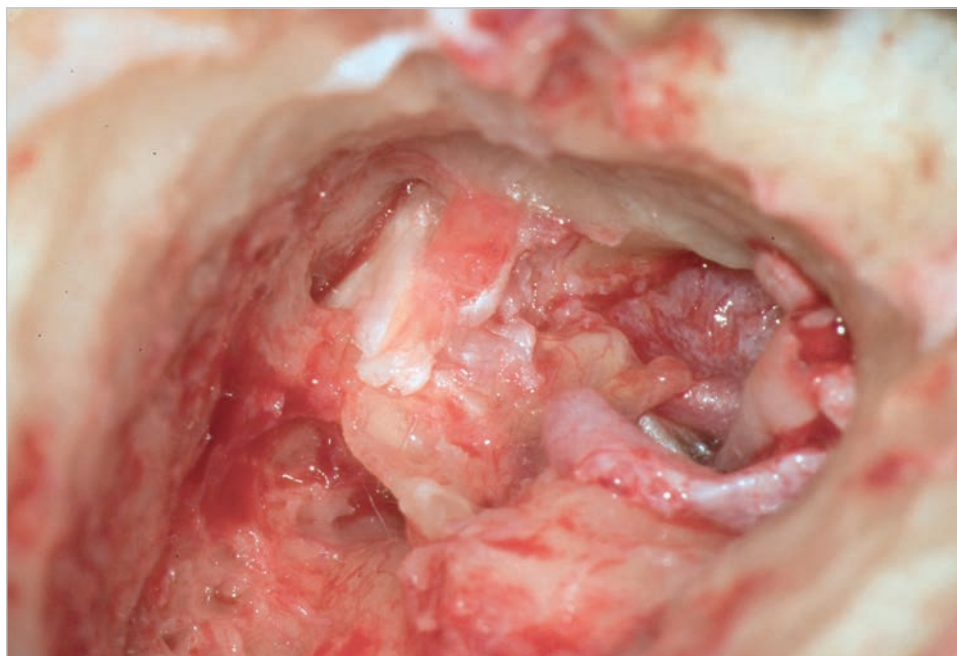


Fig. 7.112 Removal of the bone covering the supratubal recess revealed invagination of cholesteatoma into the supratubal recess.

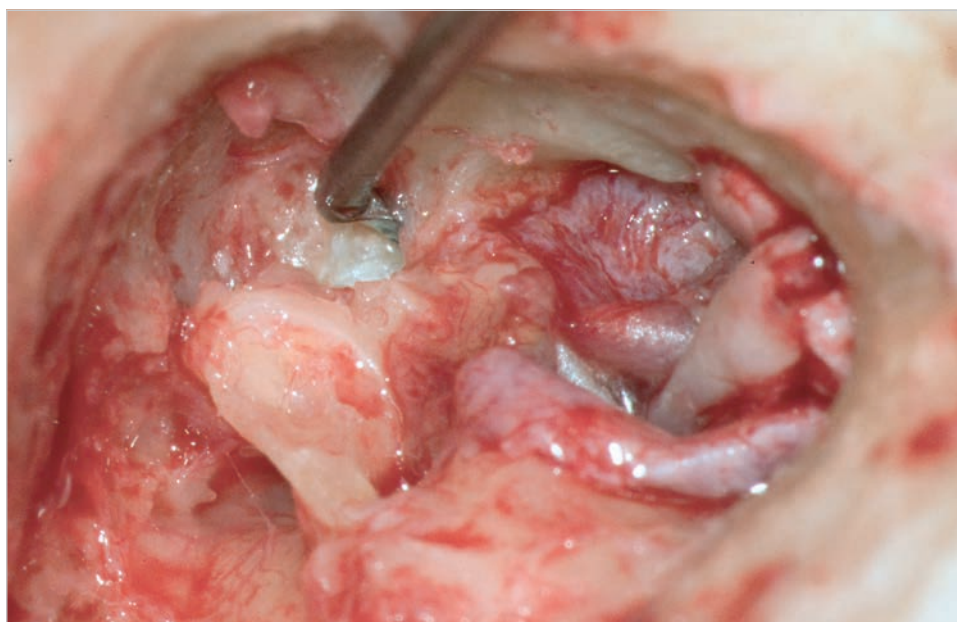


Fig. 7.113 Debulking of the cholesteatoma reveals considerable invagination of the matrix anteriorly to the malleus. Since access to this area is blocked by the ossicular chain, removal of the malleus and the incus is indicated.

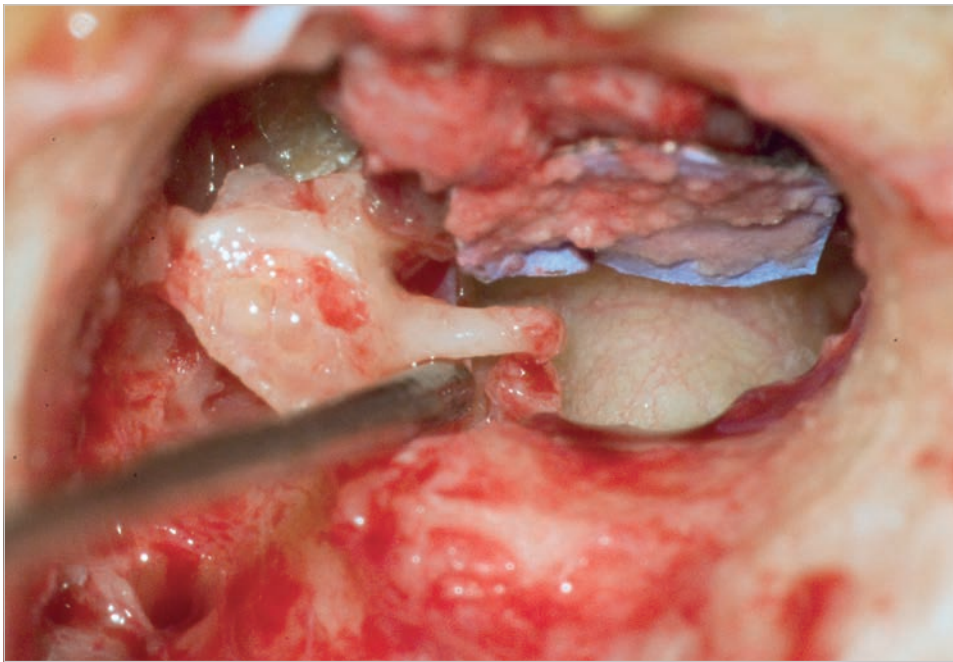


Fig. 7.114 After disarticulating the incudostapedial joint, the incus is removed.



Fig. 7.115 The head of the malleus is removed, and the tendon of the malleus is cut to widely open the area of the supratubal recess.

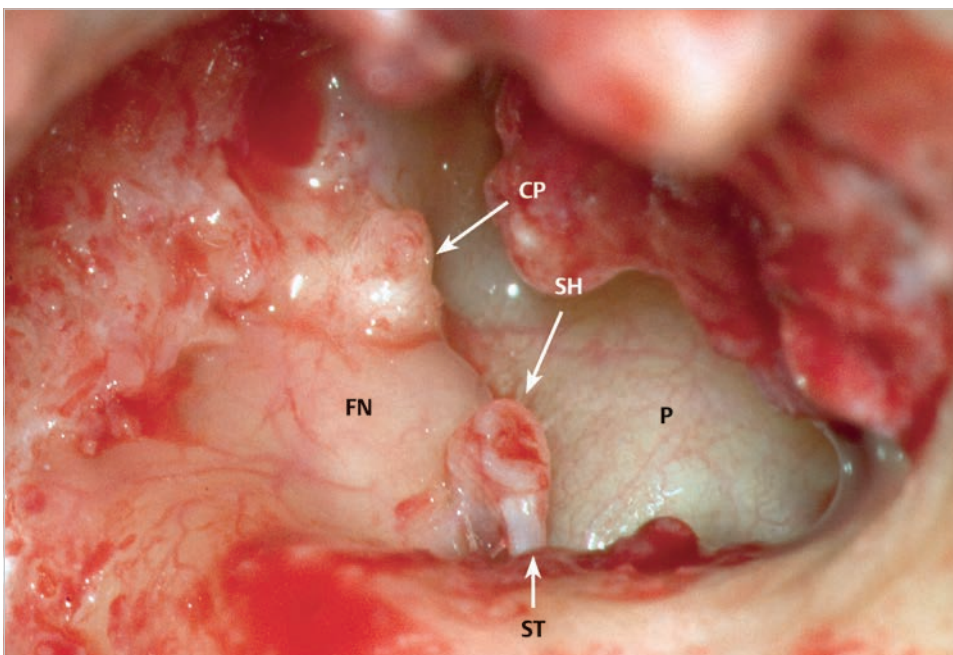


Fig. 7.116 The cholesteatoma is eradicated from the middle ear. Note that the transection of the tendon followed by inferior reflection of the tympanic membrane sufficiently enlarged the approach to the supratubal recess. The facial nerve is exposed, and protruded to touch to the stapes. CP, cochleariform process; FN, facial nerve; P, promontory; SH, head of stapes; ST, tendon of stapes.

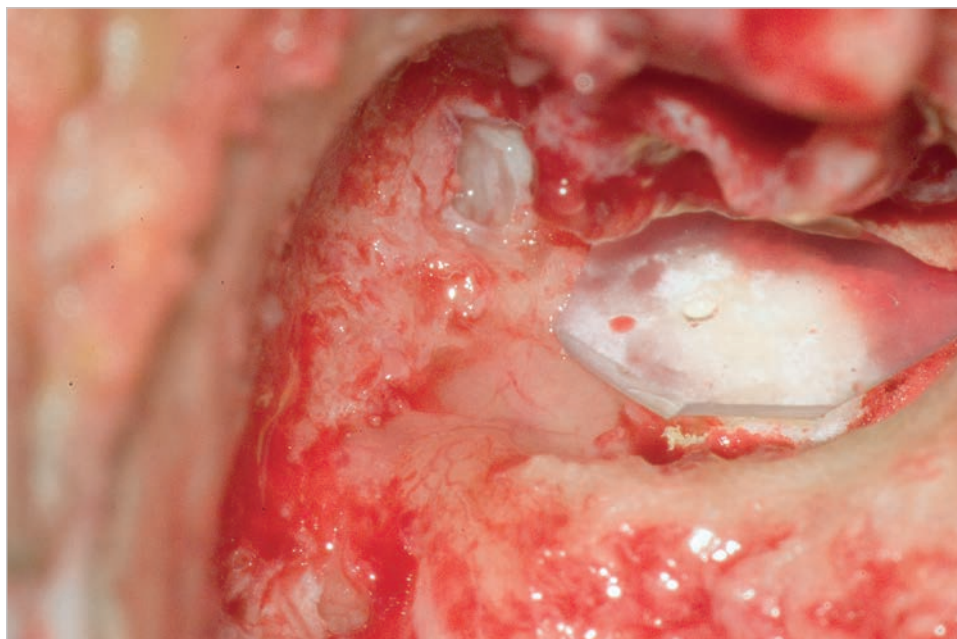


Fig. 7.117 After partially packing the tympanic cavity with Gelfoam, Silastic sheeting is placed to avoid postoperative adhesion of the tympanic membrane to the structures in the medial wall.



Fig. 7.118 A large piece of temporalis fascia is grafted underlay, and the meatal skin is replaced over the fascia. Packing of the cavity with Gelfoam follows.



Fig. 7.119 A postoperative otoscopy. Second-stage surgery is planned within 1 year.

Case 7.7 (Right Ear)

See ► Fig. 7.120, ► Fig. 7.121, ► Fig. 7.122, ► Fig. 7.123, ► Fig. 7.124, ► Fig. 7.125, ► Fig. 7.126, ► Fig. 7.127, ► Fig. 7.128, ► Fig. 7.129, ► Fig. 7.130, ► Fig. 7.131, ► Fig. 7.132, ► Fig. 7.133.

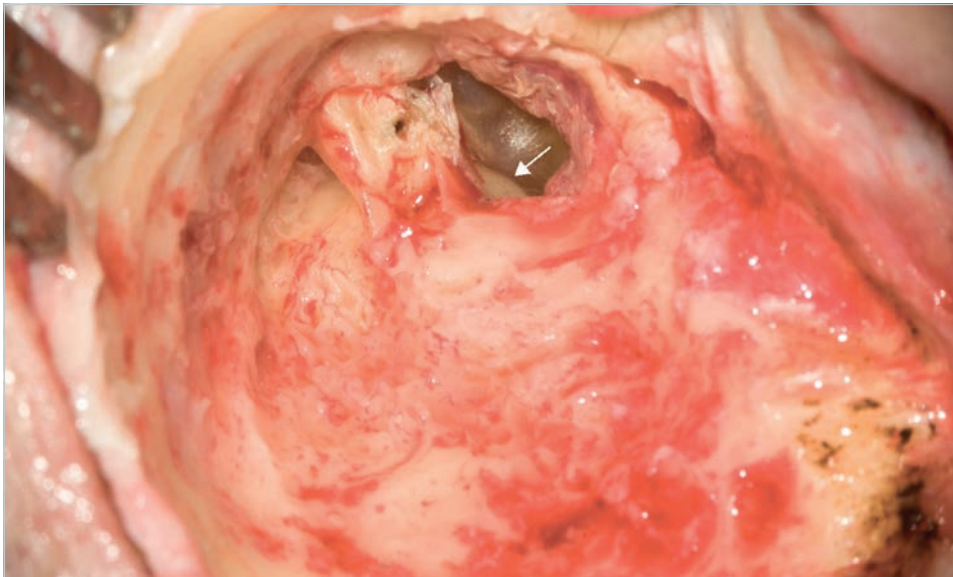


Fig. 7.120 Canal wall down mastoidectomy is carried out, and part of cholesteatoma in the mastoid is removed. No cholesteatoma is seen medially to ossicular chain. The cholesteatoma going down to the posterior part of the mesotympanum is indicated by the arrow.

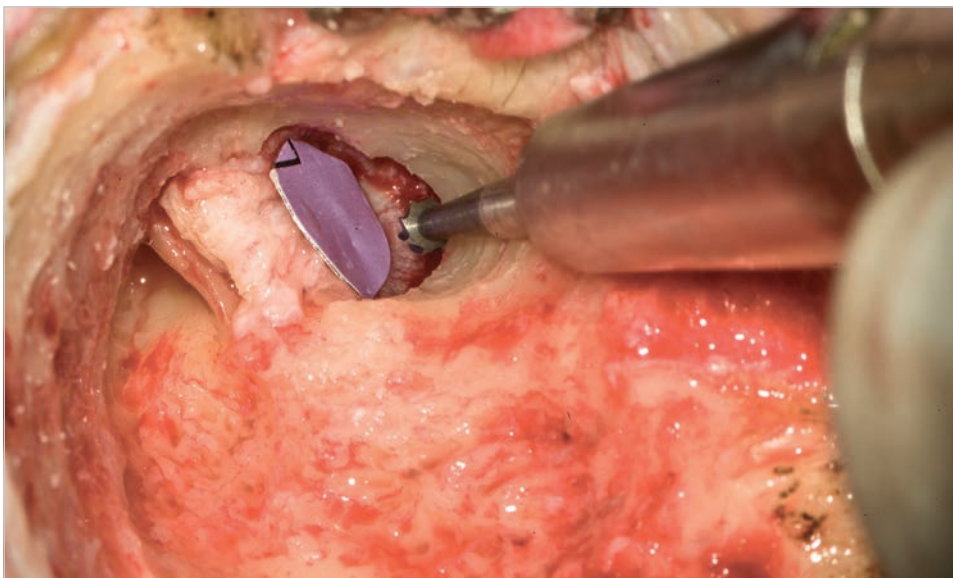


Fig. 7.121 To improve access to the tympanic cavity and to prevent postoperative open cavity problems, canaloplasty with lowering of the facial ridge is conducted. The tympanomeatal flap should be protected with aluminum sheeting.

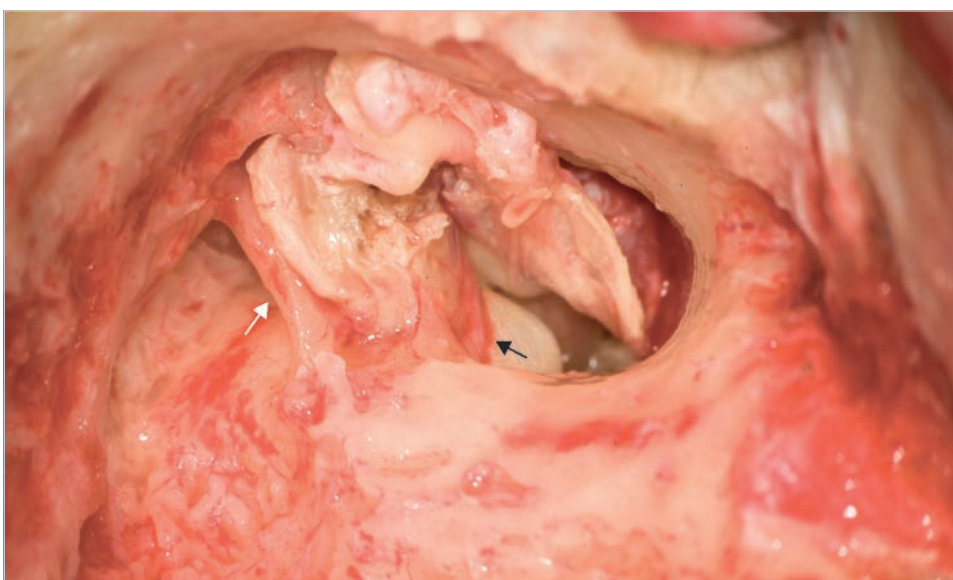


Fig. 7.122 The tympanomeatal flap is elevated and the tympanic cavity is opened. The cholesteatoma descends to the tympanic cavity through the space between the incus (white arrow) and the chorda tympani nerve (black arrow).

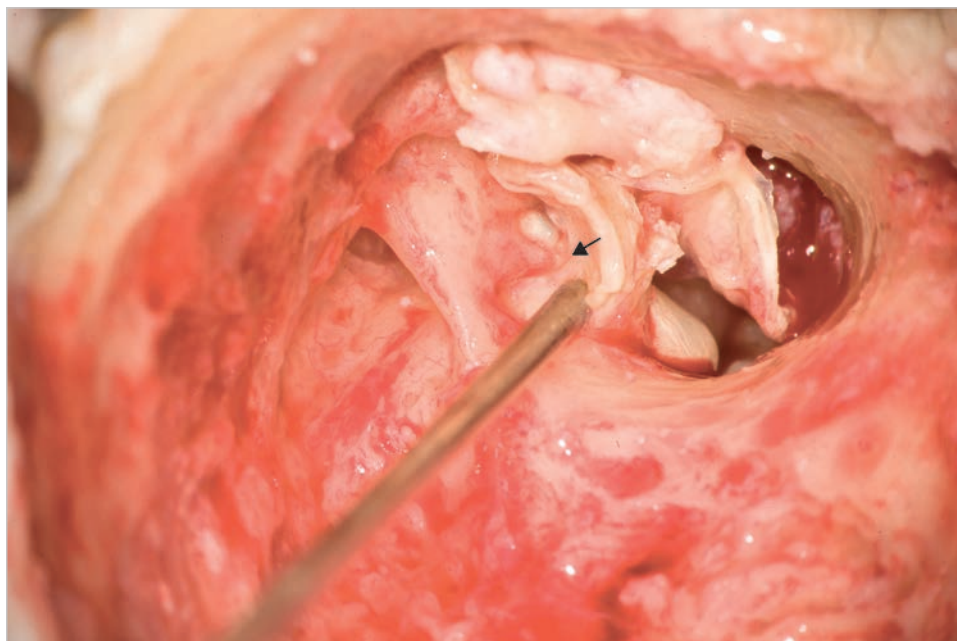


Fig. 7.123 The matrix is detached from the lateral aspect of the incus. Continuity of the ossicular chain is disturbed by an erosion of the long process of the incus (*arrow*).

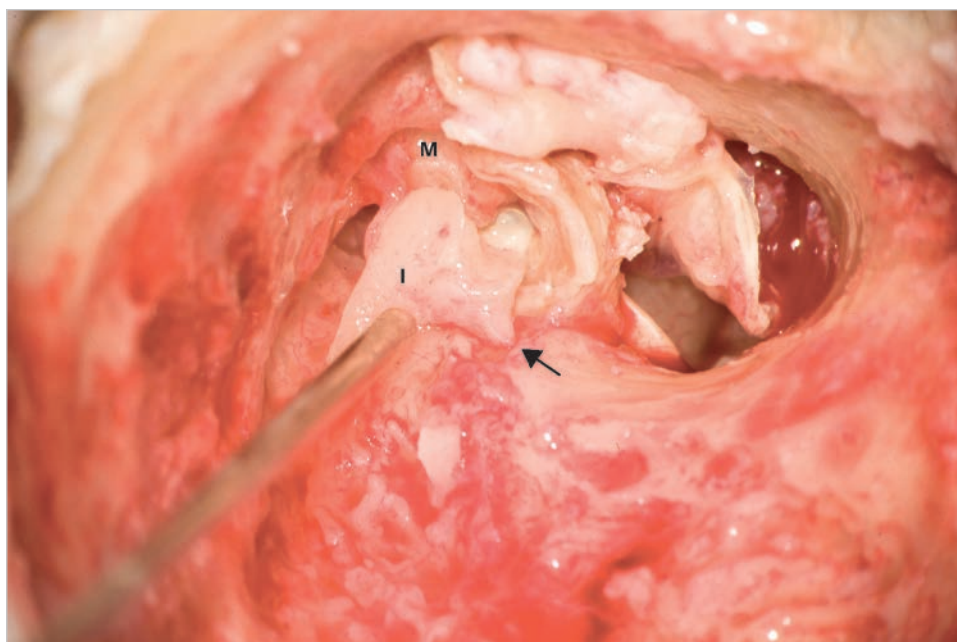


Fig. 7.124 The incus is removed. The long process is eroded (*arrow*). I, incus; M, malleus.

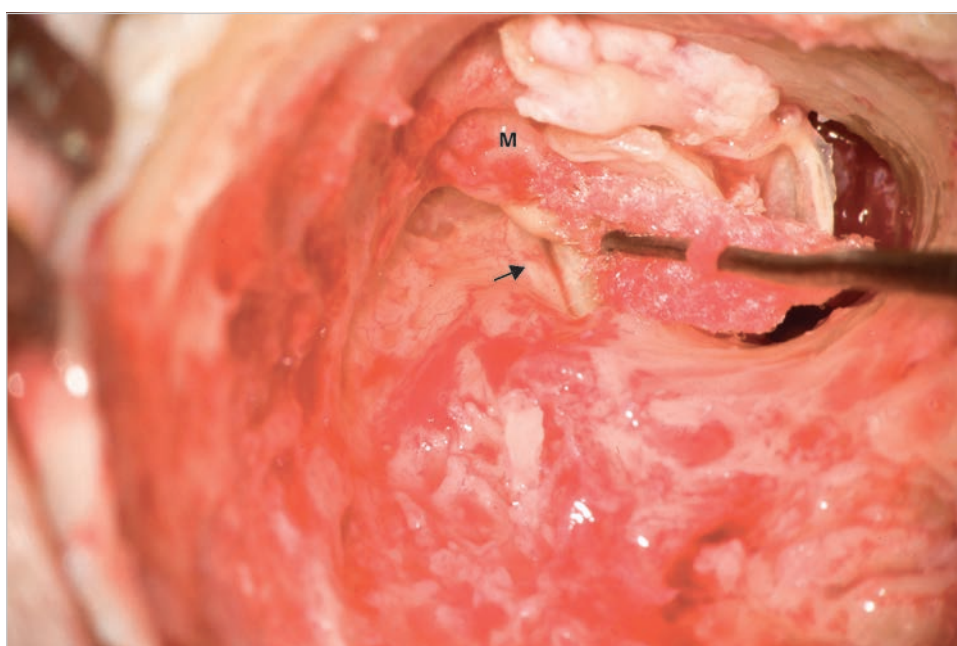


Fig. 7.125 Removal of the incus, enlarged access to the cholesteatoma. Dissection of the matrix is from the facial nerve (*arrow*) is shown. M, malleus

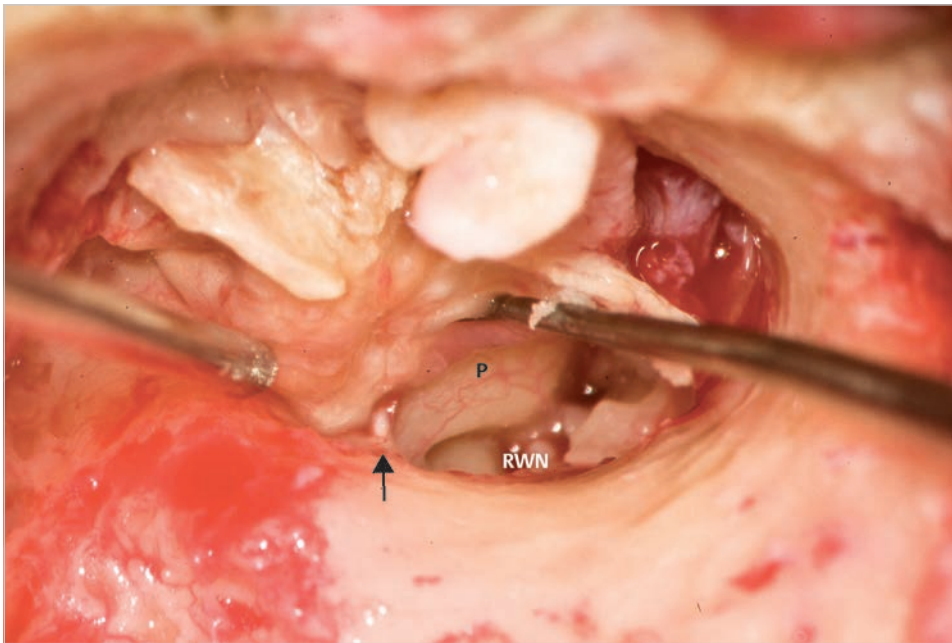


Fig. 7.126 The facial ridge is sufficiently lowered to remove the matrix is dissected from the posterior wall of the tympanic cavity. The tendon of the stapedial muscle emerging from the pyramidal eminence is seen (*arrow*). The superstructure of the stapes, if present, can be found by following the tendon anteriorly. P, promontory; RWN, round window niche.

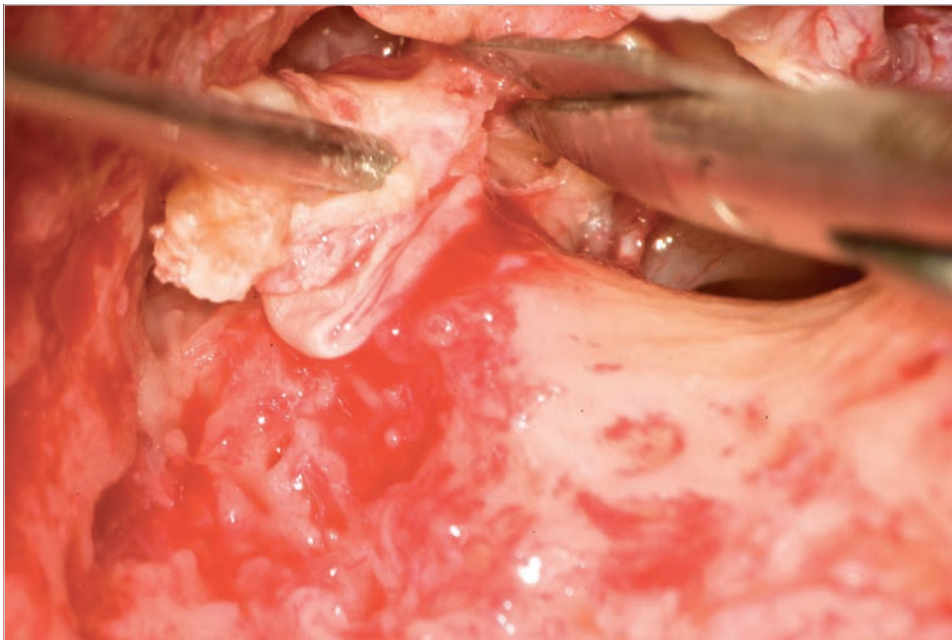


Fig. 7.127 Dissected matrix is cut away to improve view of the fragile area and to facilitate dissection without adding excessive force to the remnant of the ossicular chain.

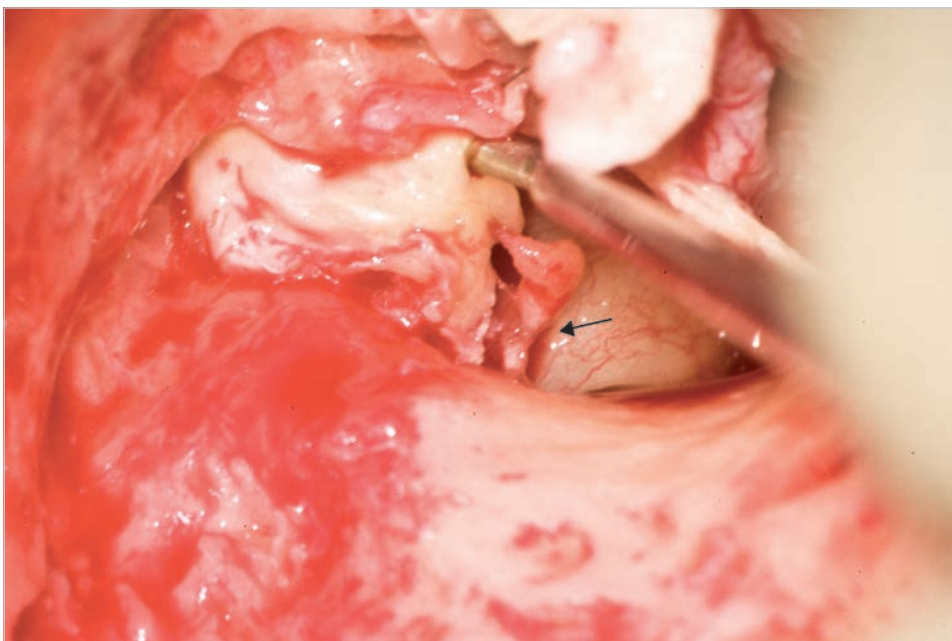


Fig. 7.128 The matrix is dissected from the stapes (*arrow*). The tip of the long process of the incus remains on the superstructure.



Fig. 7.129 The remnant of the matrix (*arrow*) covering the superstructure should be removed with great care.

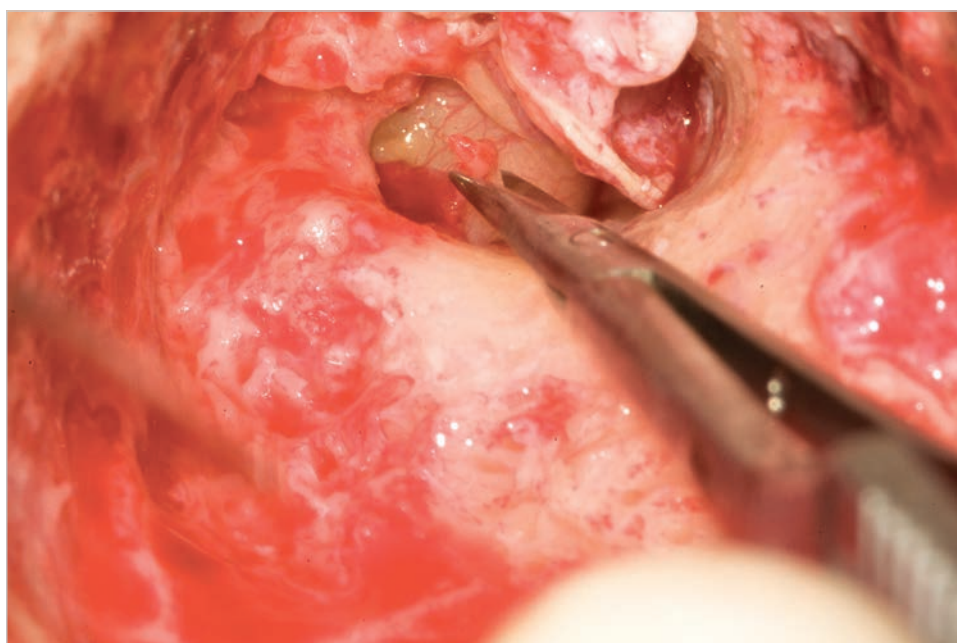


Fig. 7.130 The tip of the long process remained on the superstructure can be removed with scissors.

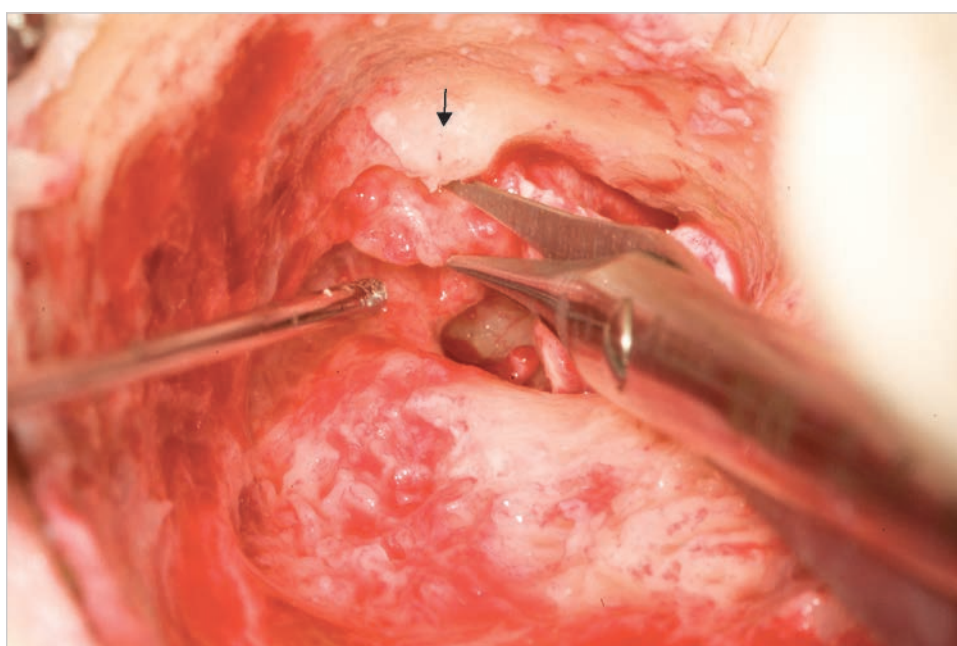


Fig. 7.131 The head of the malleus is cut. The bone covering the supratubal recess (*arrow*) should be removed.

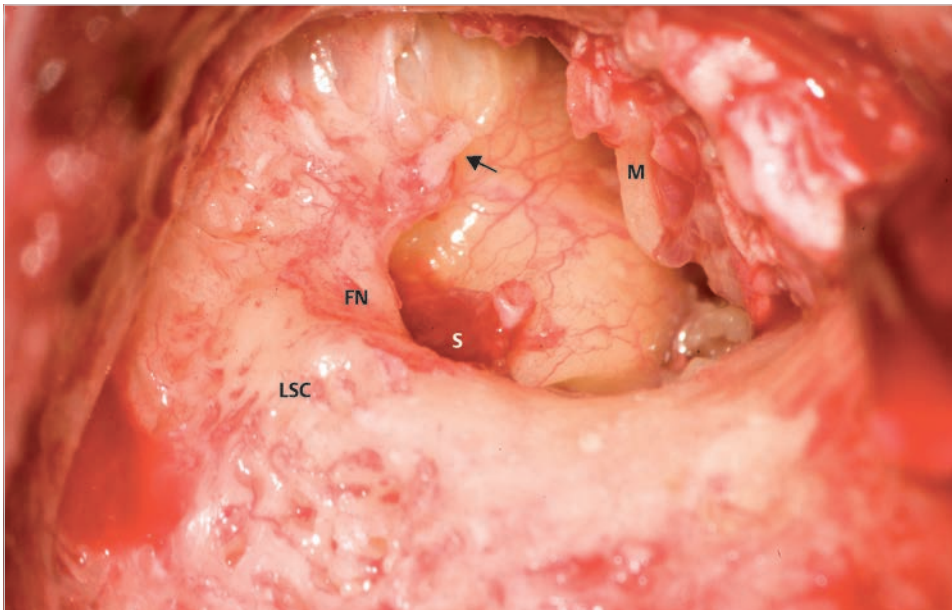


Fig. 7.132 Eradication of cholesteatoma is verified by opening the tympanic cavity fully. The tendon of the tensor tympani muscle (*arrow*) emerging from the cochleariform process is cut, and the tympanic membrane is reflected inferiorly. FN, facial nerve; LSC, lateral semicircular canal; M, malleus (handle); S, stapes.

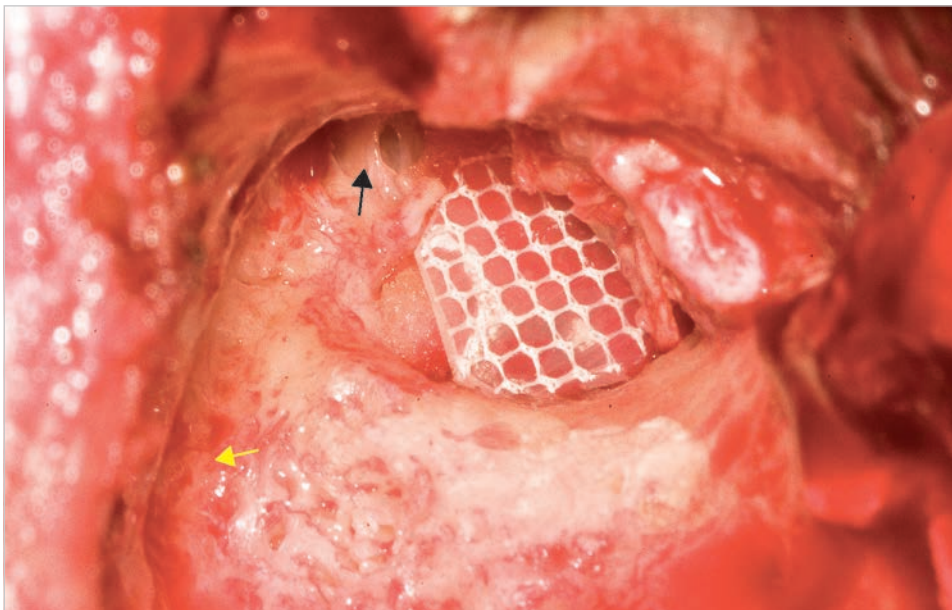


Fig. 7.133 The tympanic cavity is packed with Gelfoam, and Silastic sheeting is placed over it. The supratubal recess (*black arrow*) and a dip over the superior semicircular canal (*yellow arrow*) will be obliterated with pieces of cartilage. The cavity will be covered with a large piece of fascia, and the tympanomeatal flap is replaced over it.

Case 7.8 (Left Ear)

See ► Fig. 7.134, ► Fig. 7.135, ► Fig. 7.136, ► Fig. 7.137, ► Fig. 7.138, ► Fig. 7.139.



Fig. 7.134 Via retroauricular incision, the meatus is entered and calibration of the meatal wall is completed. A mastoidectomy is carried out to expose the posterior end of the cholesteatoma reaching the antrum. An aluminum sheeting to protect the tympanomeatal flap is seen in the bottom of the meatus.

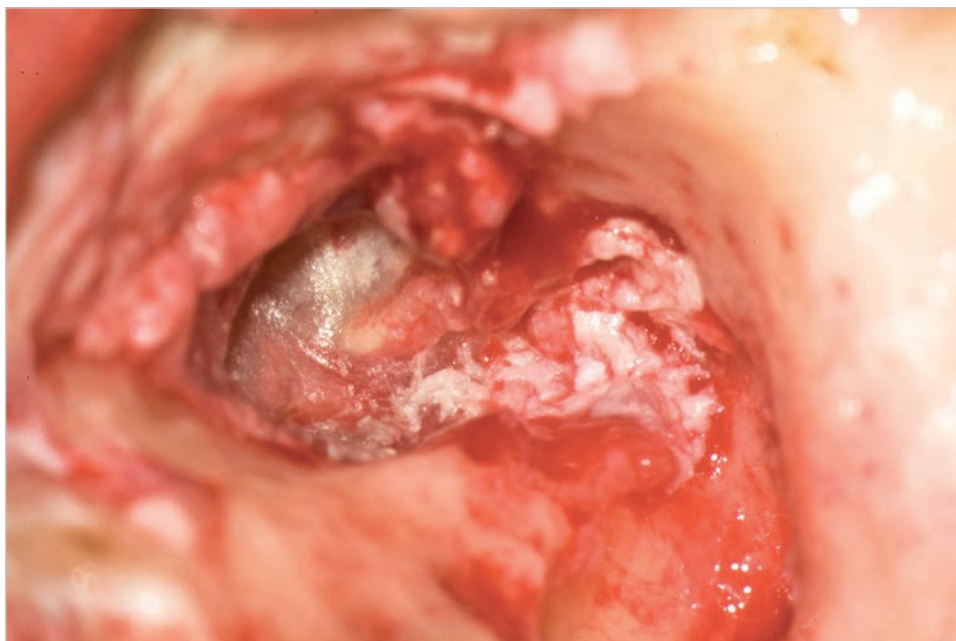


Fig. 7.135 Canal wall down mastoidectomy is carried out, and cholesteatoma invaginating from the posterosuperior quadrant is exposed. The incus is completely lost, and the superstructure of the stapes is eroded.



Fig. 7.136 Evacuation of debris permits the surgeon to push the cholesteatoma matrix inferiorly to dissect the matrix from the anterior wall of the attic. The head of the malleus (*arrow*) impeding view of this area should be removed for further dissection.

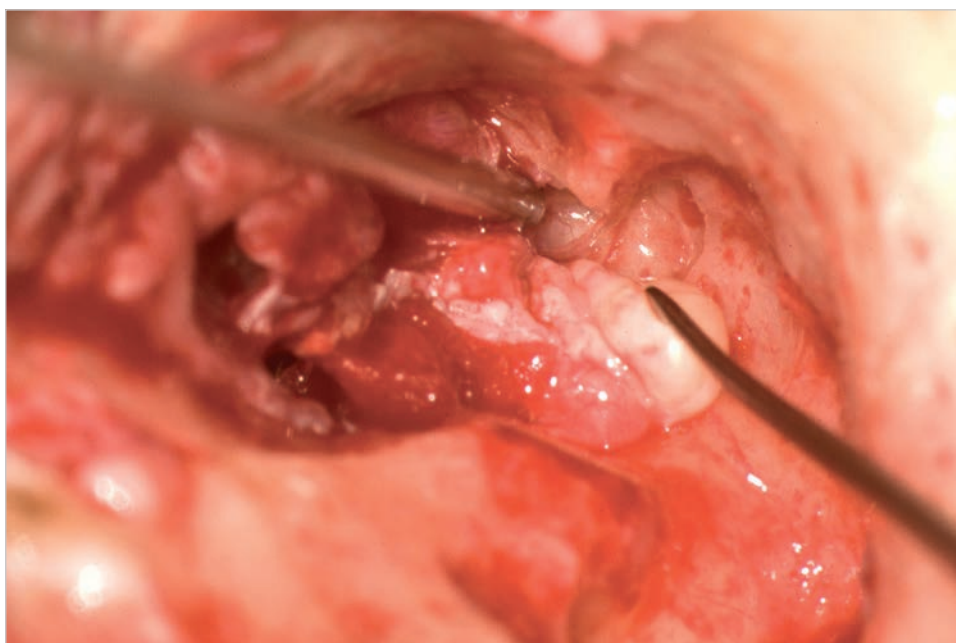


Fig. 7.137 The cholesteatoma is removed from the supratubal recess after cutting the head of the malleus.

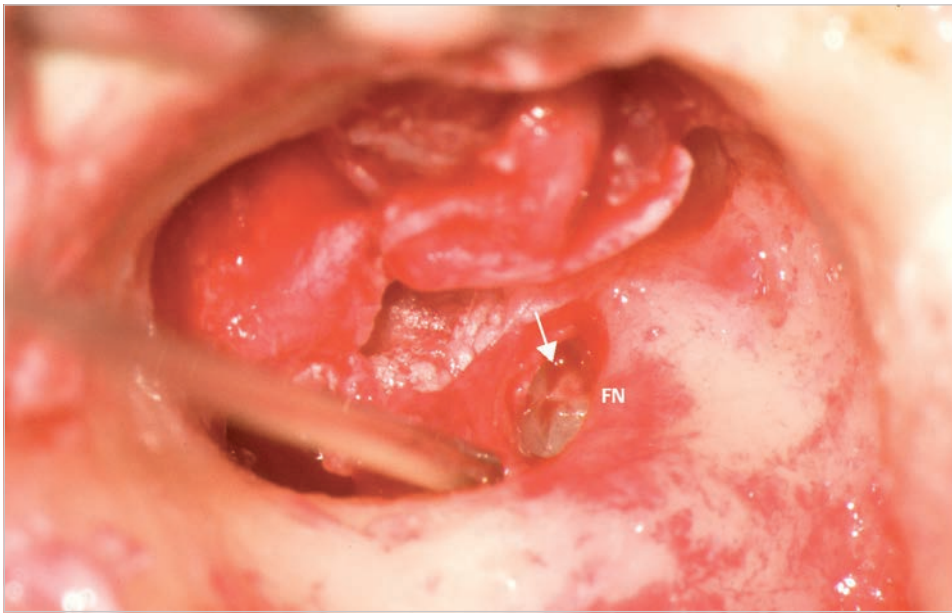


Fig. 7.138 The facial ridge is further lowered, and the matrix covering the area of the facial nerve is carefully dissected. The footplate of the stapes without the superstructure can be identified clearly (*arrow*). FN, facial nerve.

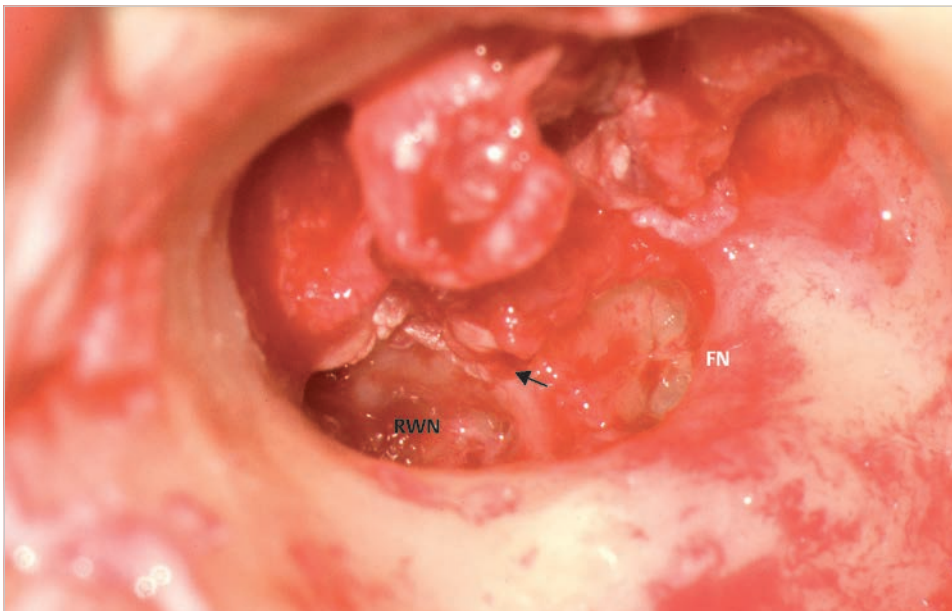


Fig. 7.139 The tympanomeatal flap is reflected anteriorly and cholesteatoma matrix adherent to the structures in the posterosuperior part of the tympanic cavity is cleaned. Note the skin still covering the promontory (*arrow*). The matrix is removed from the promontory, and Silastic sheeting is placed in the tympanic cavity. FN, facial nerve; RWN, radial window niche.

Second Stage of This Case

See ► Fig. 7.140, ► Fig. 7.141, ► Fig. 7.142, ► Fig. 7.143.

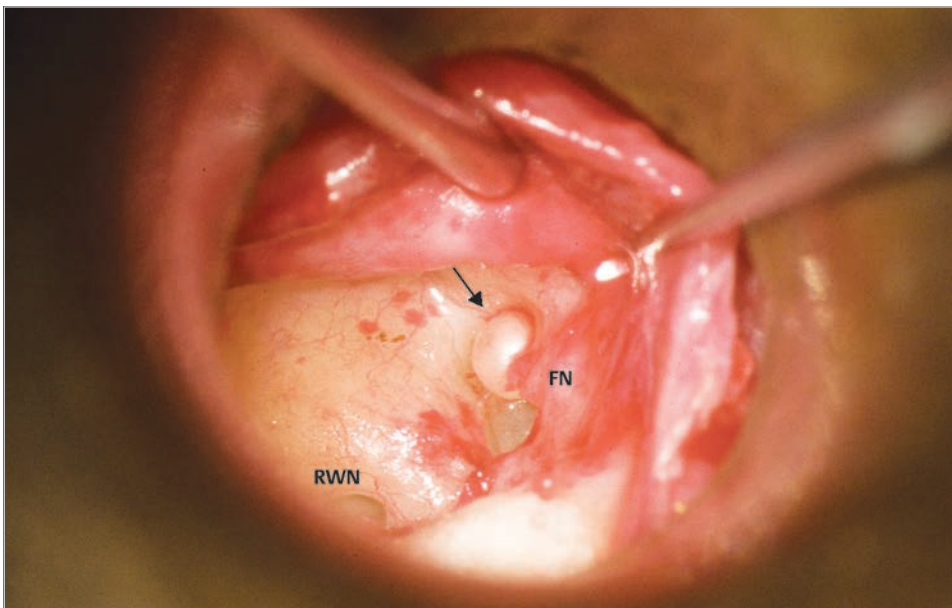


Fig. 7.140 The second-stage surgery is carried out through transmeatal approach under an ear speculum. The tympanic cavity is entered by elevating a U-shaped skin flap (see ► Fig. 7.97). A small pearl is found on the anterior part of the footplate (*arrow*). The tympanic cavity is covered with healthy mucosa. FN, facial nerve; RWN, round window niche.



Fig. 7.141 The pearl is removed taking care not to damage the exposed facial nerve and not to add excessive force to the footplate. To ensure complete removal, the pearl is elevated with the underlying scar tissue.

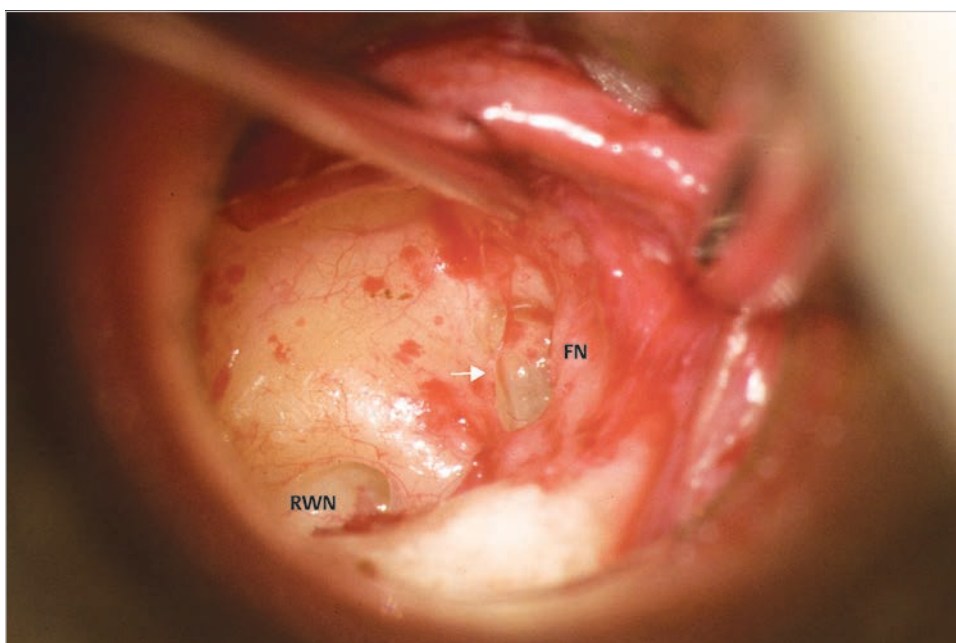


Fig. 7.142 The area of the footplate (*arrow*) cleaned is seen. FN, facial nerve; RWN, round window niche.

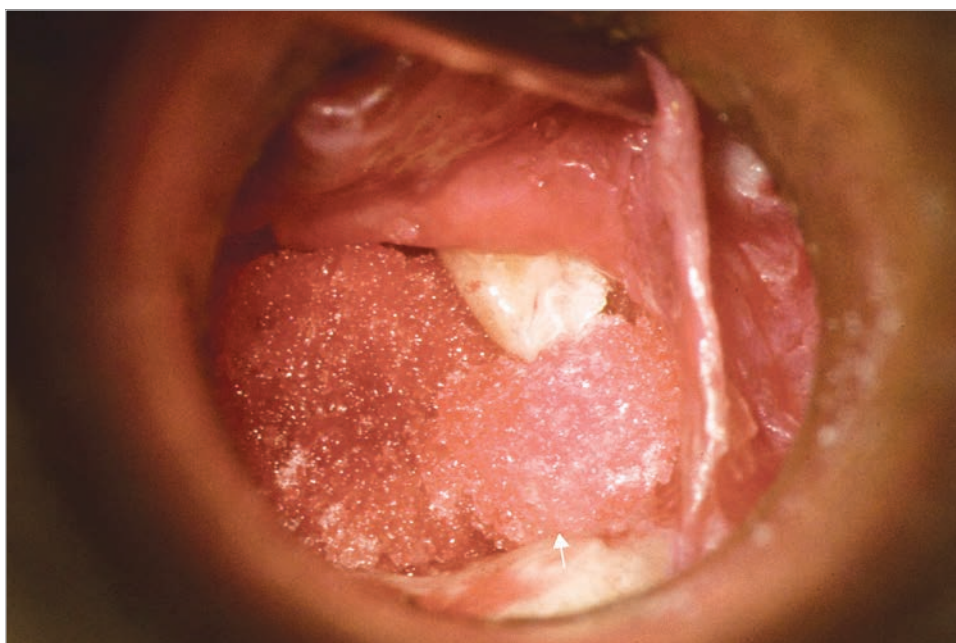


Fig. 7.143 A homologous incus is used for columella connecting the footplate and the tympanic membrane. The columella is supported by small pieces of Gelfoam. A small piece of Gelfoam (*arrow*) is placed between the posterior wall and the columella to avoid adhesion.

Case 7.9 (Left Ear)

See ► Fig. 7.144, ► Fig. 7.145, ► Fig. 7.146, ► Fig. 7.147, ► Fig. 7.148, ► Fig. 7.149, ► Fig. 7.150, ► Fig. 7.151, ► Fig. 7.152, ► Fig. 7.153, ► Fig. 7.154, ► Fig. 7.155.

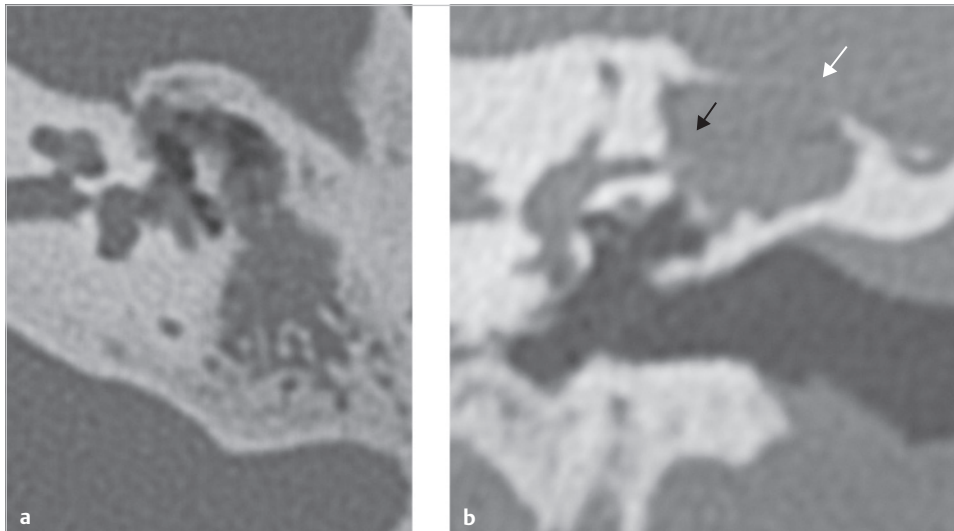


Fig. 7.144 A case of cholesteatoma with suspicion of labyrinthine fistula and exposure of the middle fossa dura. **(a)** The axial CT shows heavy erosion of the ossicular chain. **(b)** The coronal CT indicates possibilities of exposed middle fossa dura (*white arrow*), and a fistula in the lateral semicircular canal (*black arrow*).



Fig. 7.145 The meatus is opened via retroauricular incision. Bone erosion is seen in the pars flaccida of the tympanic membrane (*yellow arrow*). Bony protrusions in the anterior and inferior walls narrow the meatus. To calibrate the anterior wall, the anterior meatal skin is cut circumferentially (*black arrow*).

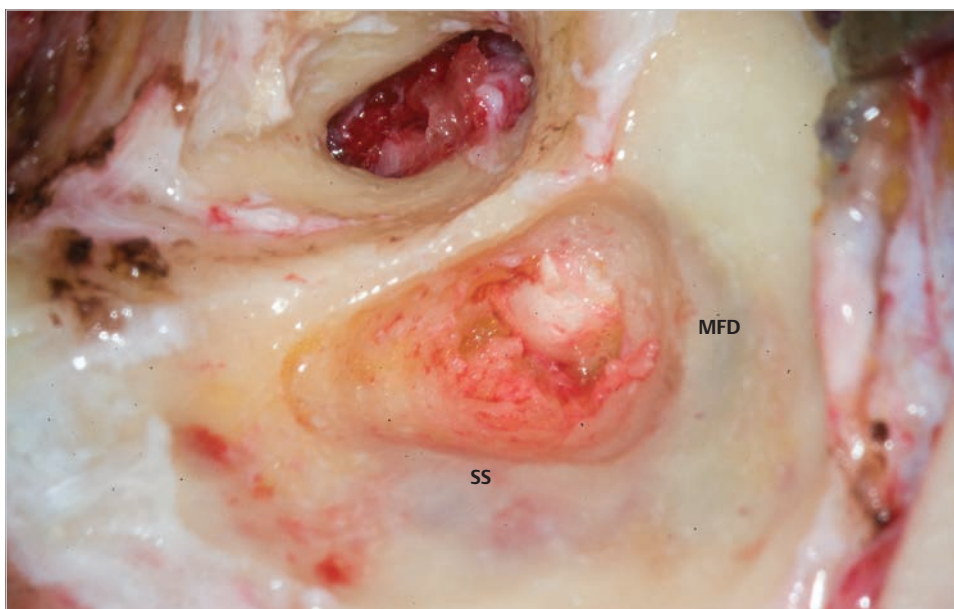


Fig. 7.146 The sigmoid sinus and the middle fossa dura are identified, and mastoidectomy is advanced medially to open the antrum. Cholesteatoma occupying the antrum is started to be seen. Note that no acute angle is left on edges, and the cavity is well saucerized. MFD, middle fossa dura; SS, sigmoid sinus.



Fig. 7.147 The posterior meatal wall is removed, and the cholesteatoma is opened to evacuate debris. No fistula is identified in the lateral semicircular canal. Meatoplasty is carried out to obtain round-shaped cavity.

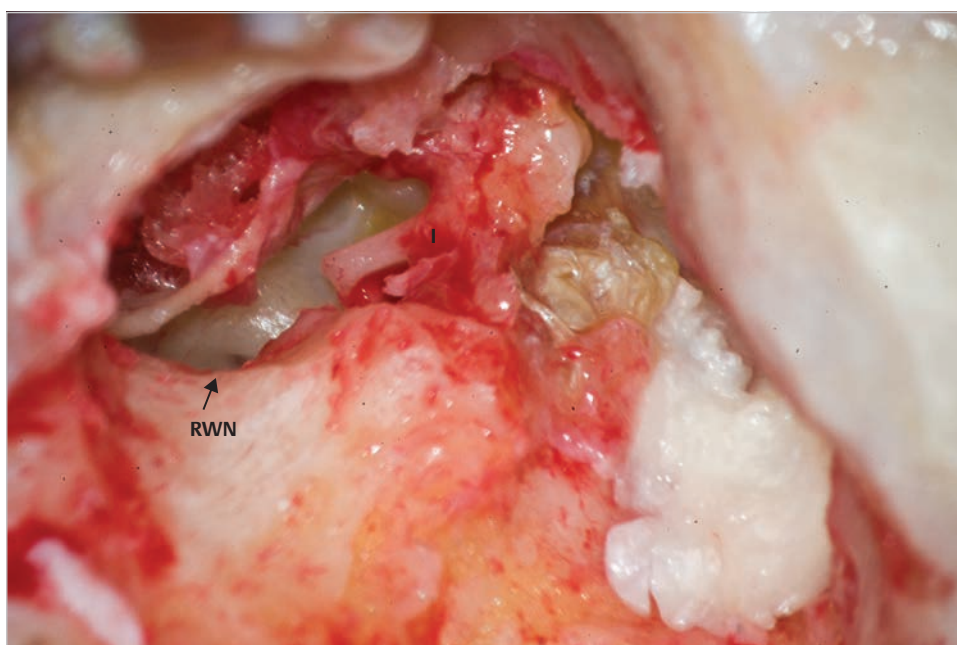


Fig. 7.148 The tympanic cavity is opened from posterior, and the chorda tympani nerve is cut. The cholesteatoma erodes the superior aspect of the body of the incus, and goes medially to the ossicular chain. I, incus; RWN, round window niche.

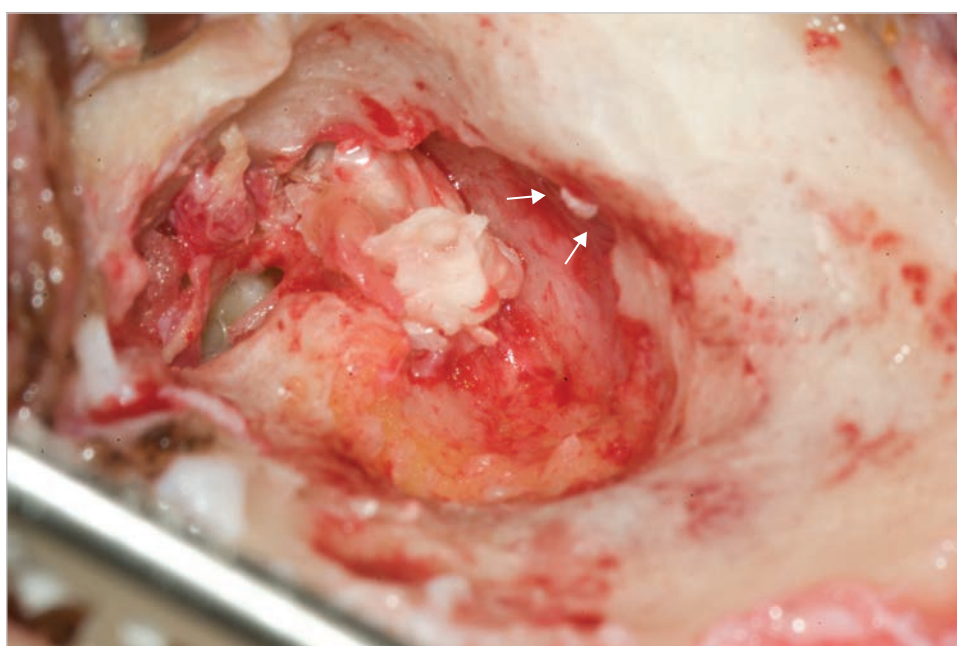


Fig. 7.149 Dissection of the matrix from the mastoid is advanced anteriorly. A small area of the middle fossa dura is exposed in the tegmen of the mastoid (arrows). The matrix is dissected from the dura without difficulty.

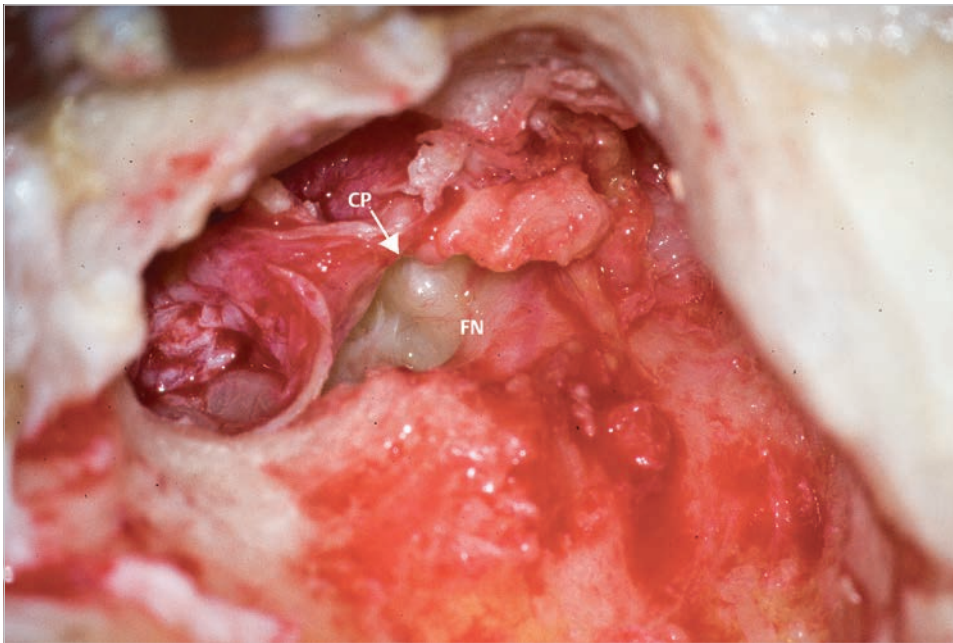


Fig. 7.150 After disarticulating the incudostapedial joint, the incus is removed to dissect the matrix behind the ossicular chain. The tympanic segment of the facial nerve is seen. No fistula is found in the lateral semicircular canal. CP, cochleariform process; FN, facial nerve.

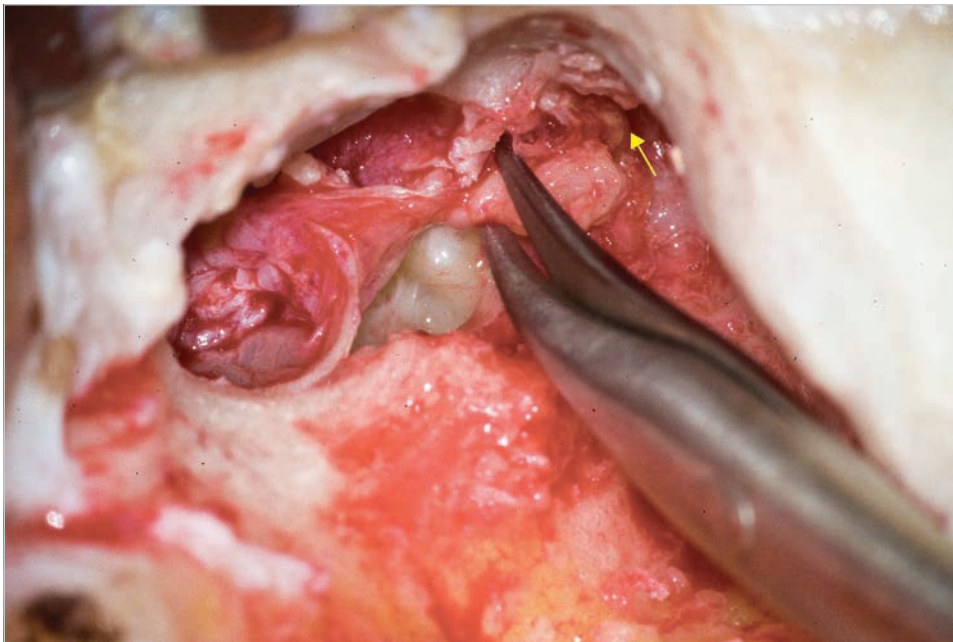


Fig. 7.151 To remove cholesteatoma occupying the supratubal recess (*arrow*), the head of the malleus is cut with scissors.

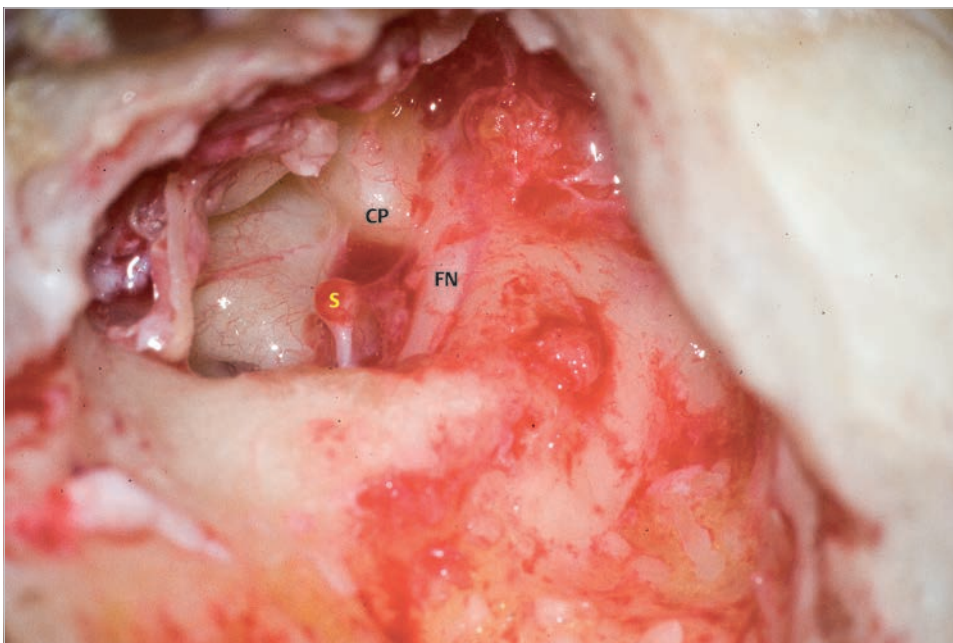


Fig. 7.152 The supratubal recess is opened, and the cholesteatoma is eradicated from the middle ear. CP, cochleariform process; FN, facial nerve; S, stapes.



Fig. 7.153 The tympanomeatal flap is replaced, and the final shape of the cavity is shown. The pars tensa of the tympanic membrane remains intact.

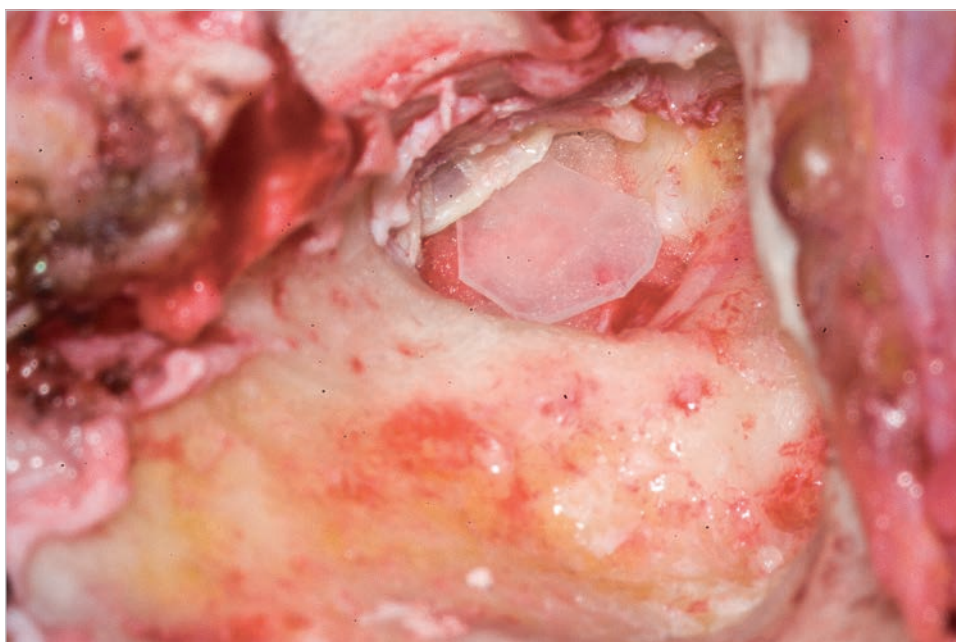


Fig. 7.154 To prevent adhesion of the tympanic membrane, Silastic sheeting is placed over the Gelfoam.

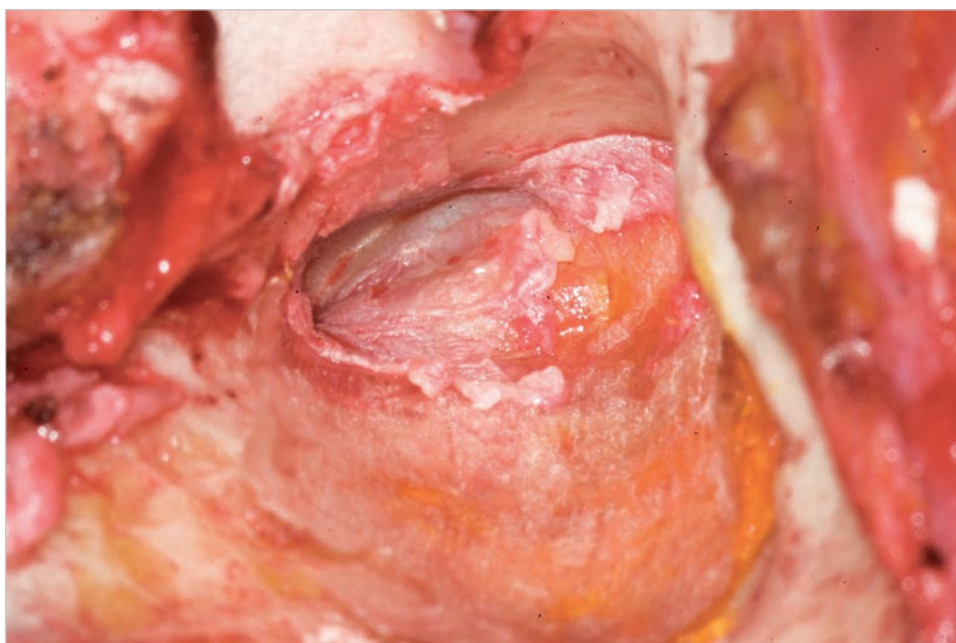


Fig. 7.155 Cartilage harvested in meatoplasty and bone paste is used to obliterate the area of the mastoid tip, medial walls of the attic and the antrum, and the exposed middle fossa dura. The temporalis fascia is grafted underlay, and the tympanomeatal flap is replaced over the fascia.

Second Stage of This Case

See ► Fig. 7.156, ► Fig. 7.157, ► Fig. 7.158, ► Fig. 7.159.



Fig. 7.156 The postoperative otoscopy after the first stage shows well-epithelized, easy-to-manage small cavity. Silastic sheeting placed in the tympanic cavity is seen through the tympanic membrane.



Fig. 7.157 The second-stage surgery is conducted under the ear speculum by creating a U-shaped tympanomeatal flap. Opening of the tympanic cavity from inferior exposed the Silastic sheeting placed in the first-stage surgery. Note that the tympanic cavity is covered with healthy mucosa.

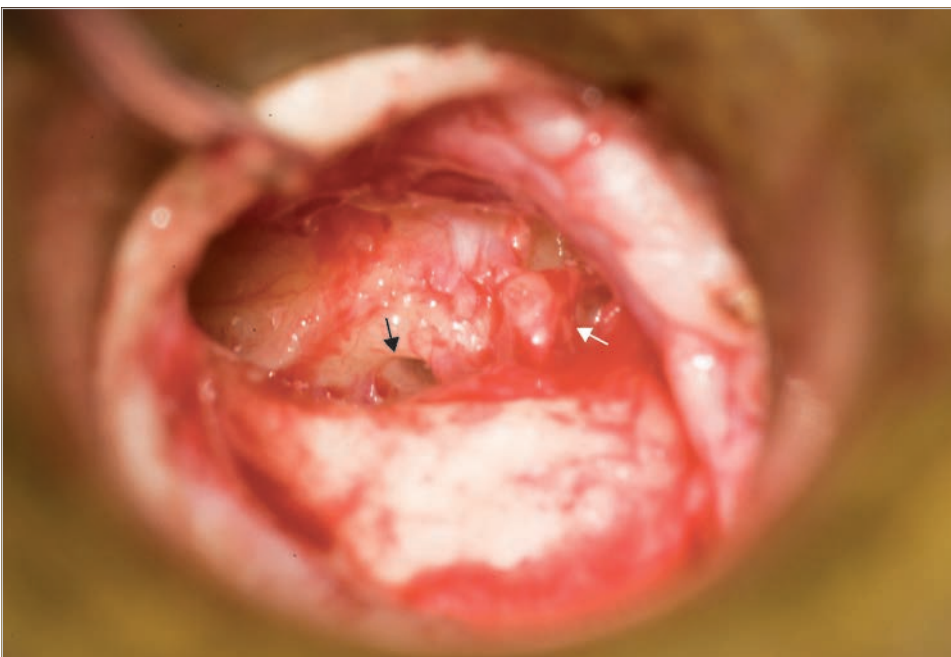


Fig. 7.158 Status of the tympanic cavity is shown. The stapes (*white arrow*) kept good mobility, and the round window niche is clearly seen (*black arrow*).



Fig. 7.159 After packing the tympanic cavity, a piece of tragal cartilage is placed over the head of the stapes. The cartilage works as columella, and prevents retraction of the posterosuperior quadrant simultaneously. The tympanic cavity will be closed by replacing the tympanomeatal flap.

Case 7.10 (Left Ear)

See ▶ Fig. 7.160, ▶ Fig. 7.161, ▶ Fig. 7.162, ▶ Fig. 7.163, ▶ Fig. 7.164, ▶ Fig. 7.165, ▶ Fig. 7.166, ▶ Fig. 7.167, ▶ Fig. 7.168, ▶ Fig. 7.169.



Fig. 7.160 The external auditory canal is opened, and mastoidectomy is started after exposing the lateral face of the mastoid widely. A large erosion is seen in the attic.

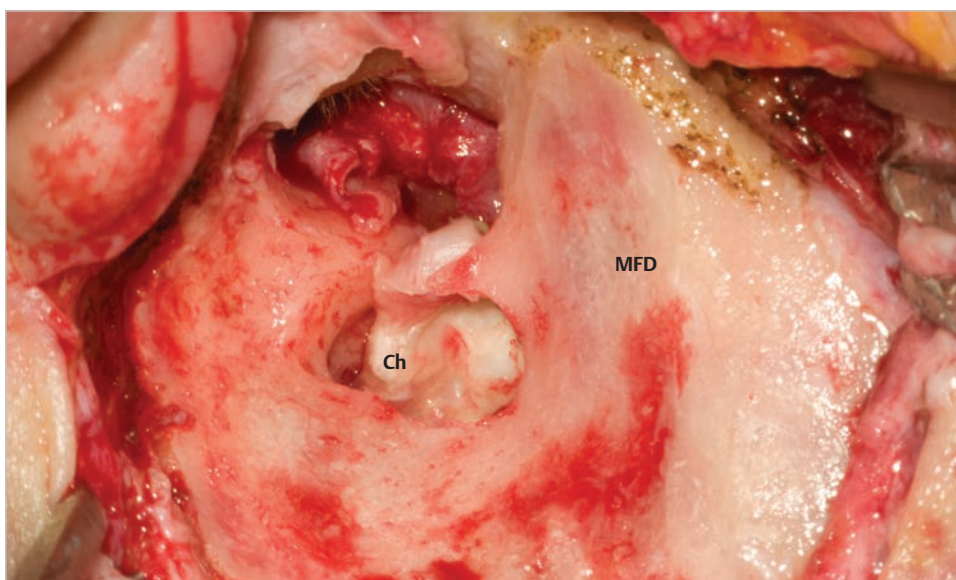


Fig. 7.161 Canal wall down mastoidectomy is started. The middle fossa dura is identified superiorly as a pinkish aspect. Sharp bony protrusions should be eliminated to widen maximally the access to the middle ear. Ch, cholesteatoma; MFD, middle fossa dura.

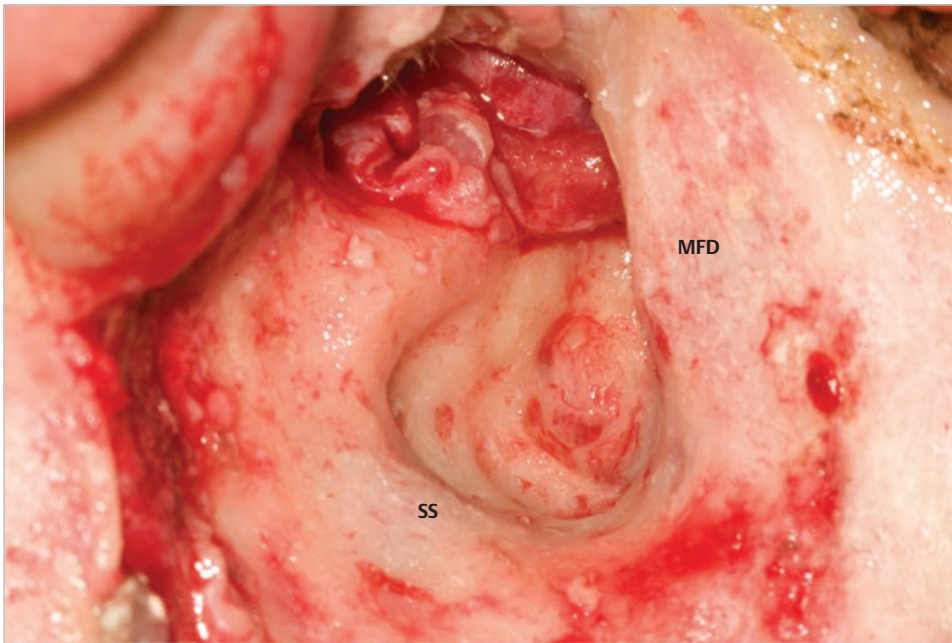


Fig. 7.162 The sigmoid sinus is identified posteriorly as a bluish area. The wide opening permits reliable dissection of cholesteatoma, and simultaneously, reduces risk of postoperative open cavity problems. MFD, middle fossa dura; SS, sigmoid sinus.

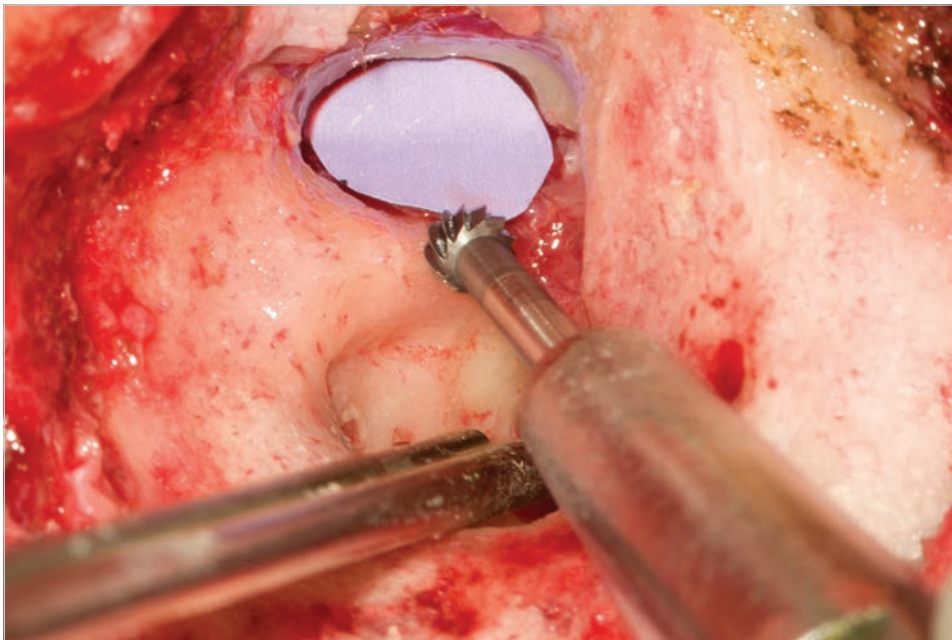


Fig. 7.163 The facial ridge should be lowered sufficiently. A cutting burr is moved parallel to the facial nerve to avoid damaging it.

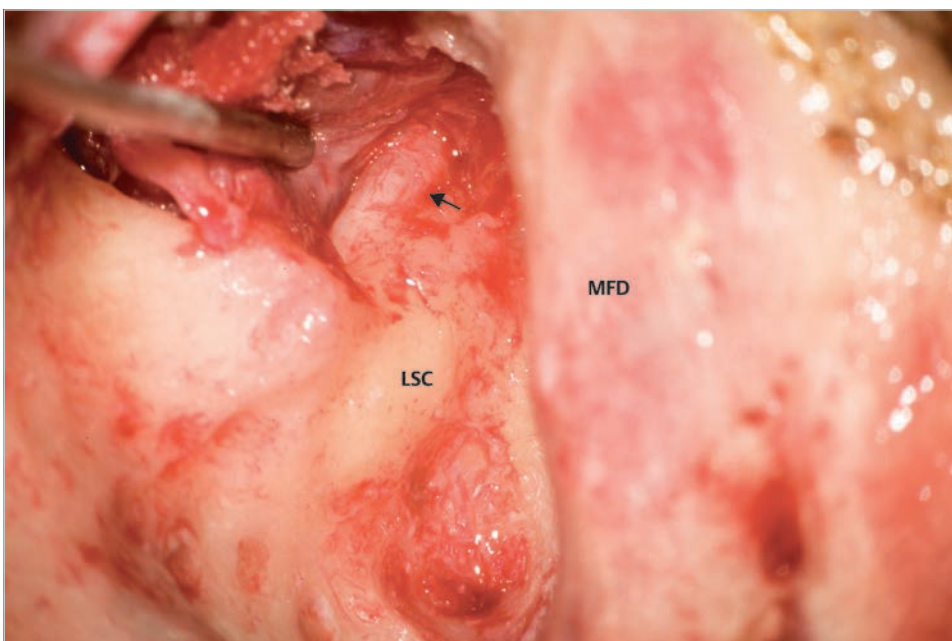


Fig. 7.164 The matrix is detached from the facial nerve (arrow). Note that the nerve is uncovered extensively in the tympanic segment. LSC, lateral semicircular canal; MFD, middle fossa dura.

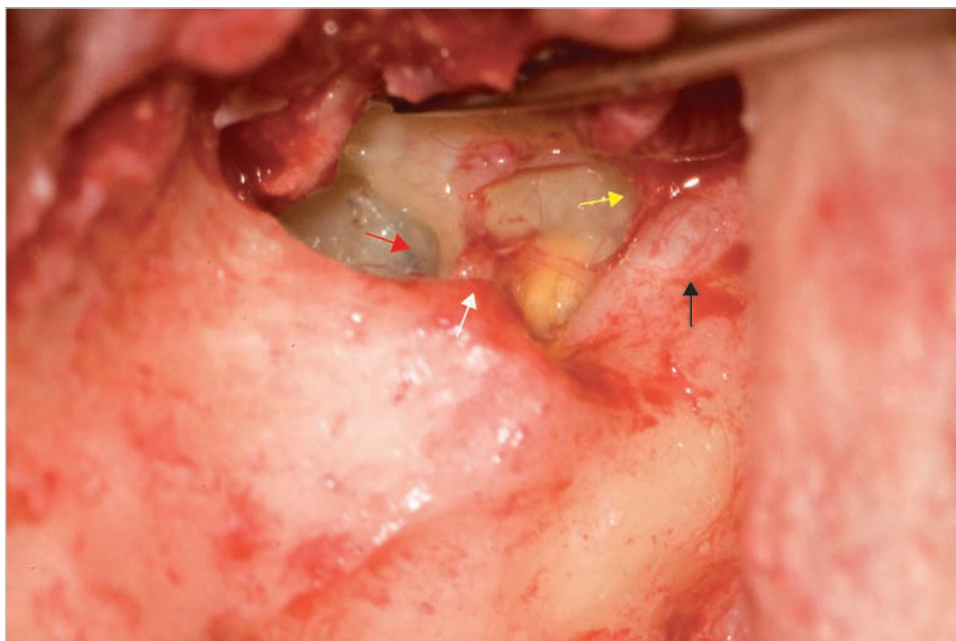


Fig. 7.165 Enlarged view. The facial nerve is partially exposed (*black arrow*). The head of the stapes (*white arrow*) and the round window (*red arrow*) can be identified. A mucosal cyst containing yellowish exudate covers the footplate. Note the relationships between the cochleariform process and the nerve (*yellow arrow*).

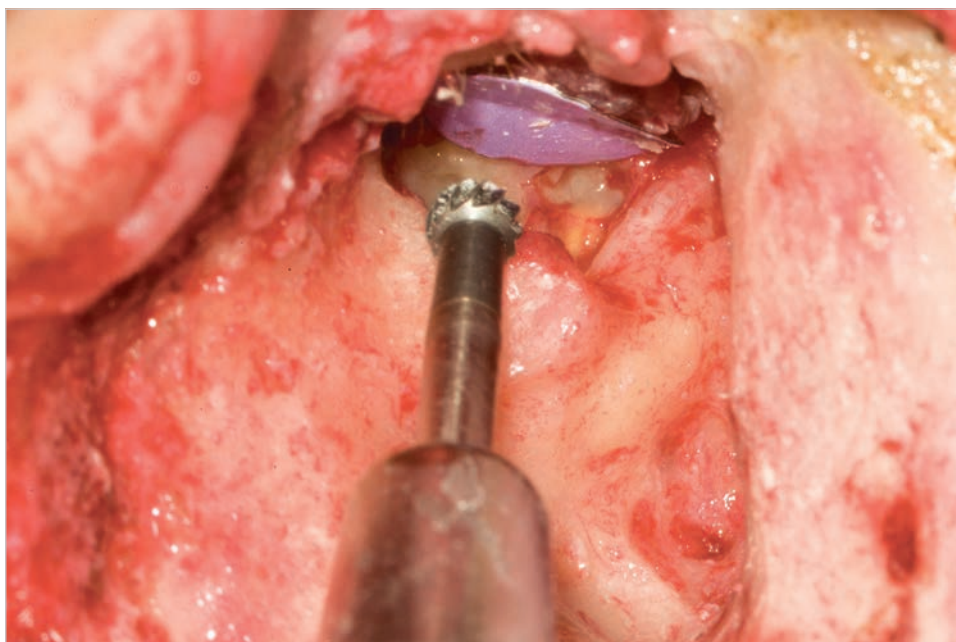


Fig. 7.166 The facial ridge is lowered with a cutting burr. The movement should always be parallel to the facial nerve. At the same time, never move the burr toward the exposed tympanic segment of the facial nerve, or toward the stapes.

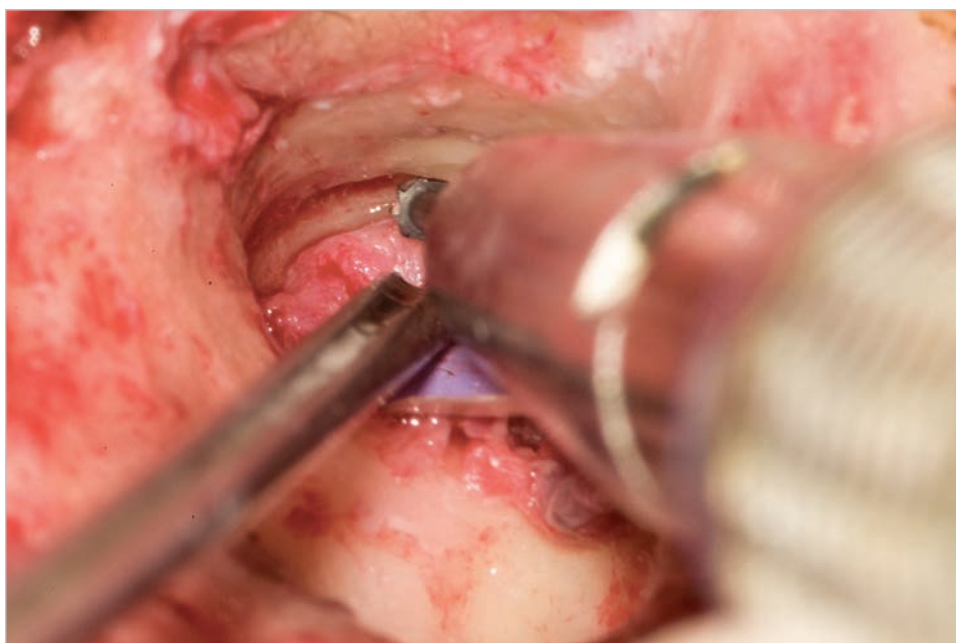


Fig. 7.167 To control the tympanic membrane, the anterior and inferior walls of the bony meatus should be calibrated.

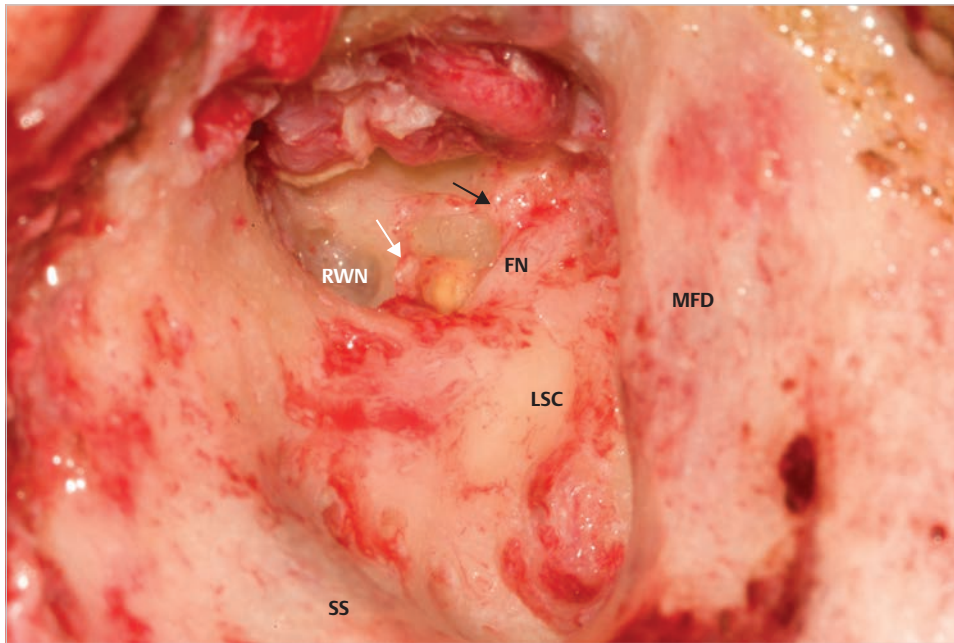


Fig. 7.168 The final shape of the cavity is shown. Note the well-saucerized and rounded cavity with sufficiently low facial ridge. The white arrow indicates the superstructure of the stapes, and the black arrow, the cochleariform process. FN, facial nerve; LSC, lateral semicircular canal; MFD, middle fossa dura; RWN, round window niche; SS, sigmoid sinus.

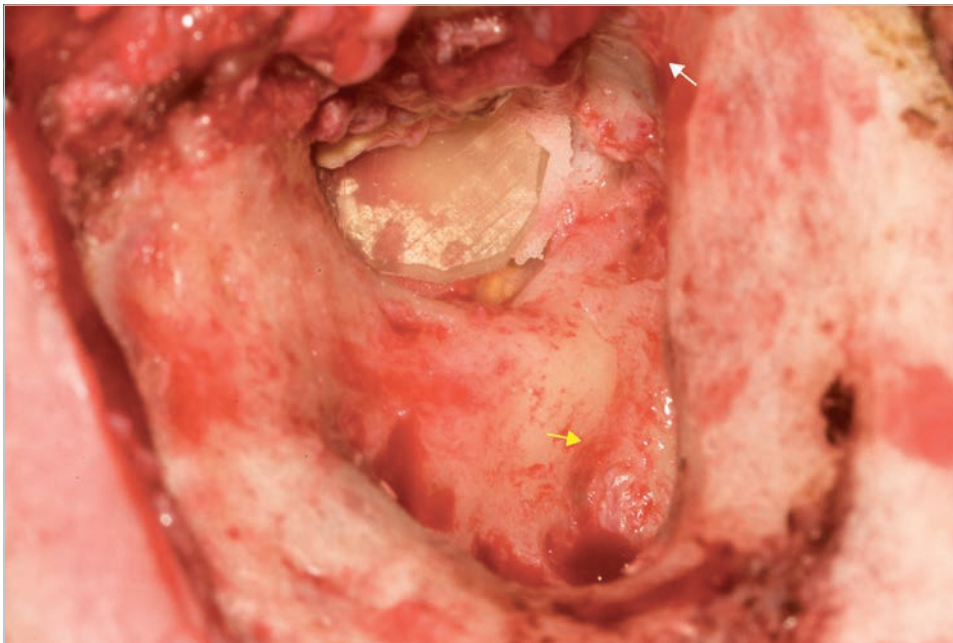


Fig. 7.169 The cavity is packed with Gelfoam, and a Silastic sheeting is placed over it. The supratubal recess (*white arrow*) and a dip in the perilabyrinthine area (*yellow arrow*) are obliterated with small pieces of cartilage, and a large piece of temporalis fascia is grafted underlay to cover the bony wall of the cavity.

7.1.4 Conversion from Canal Wall Up to Down

According to our strategy, reformation of cholesteatoma after CWU tympanoplasty is an indication of removal of the posterior wall. The recurrence indicates sustained underlying pathogenesis, and difficulty of its control. An application of the same technique likely to impose further risks and inconvenience to the patient and family. Removal of the posterior wall considerably reduces the spaces and gaps that may accommodate ingrown skin, resulting in reduction of recurrence. In addition, improved visibility facilitates complete removal of the disease.

Formation of a small retraction pocket after the first-stage surgery may be corrected by reinforcing the retraction with either bone paste or cartilage in the second stage. However, in case of a large pocket accumulating debris, we do not hesitate removing the posterior wall in the second stage. If the second stage is planned before cholesteatoma affects status of mucosa in the tympanic cavity, ossiculoplasty may be performed in one stage.

Case 7.11 (Right Ear)

See ▶ Fig. 7.170, ▶ Fig. 7.171, ▶ Fig. 7.172, ▶ Fig. 7.173, ▶ Fig. 7.174, ▶ Fig. 7.175, ▶ Fig. 7.176, ▶ Fig. 7.177, ▶ Fig. 7.178.

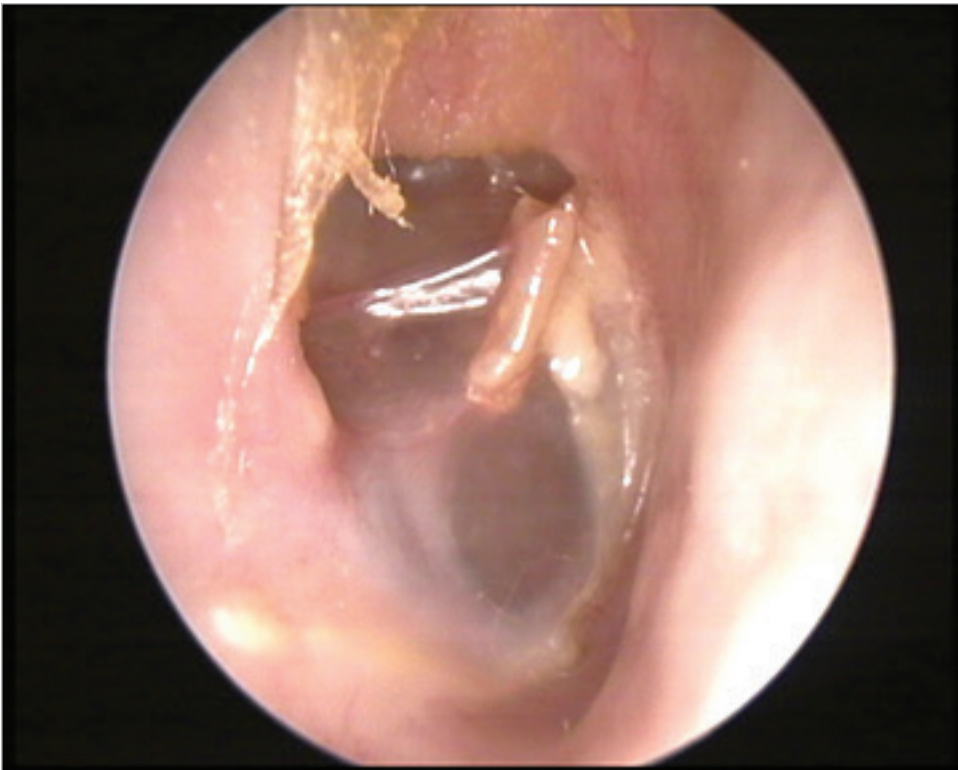


Fig. 7.170 A case of recurrent cholesteatoma after first-stage canal wall up tympanoplasty. A deep retraction is identified in the posterosuperior quadrant of the tympanic membrane.

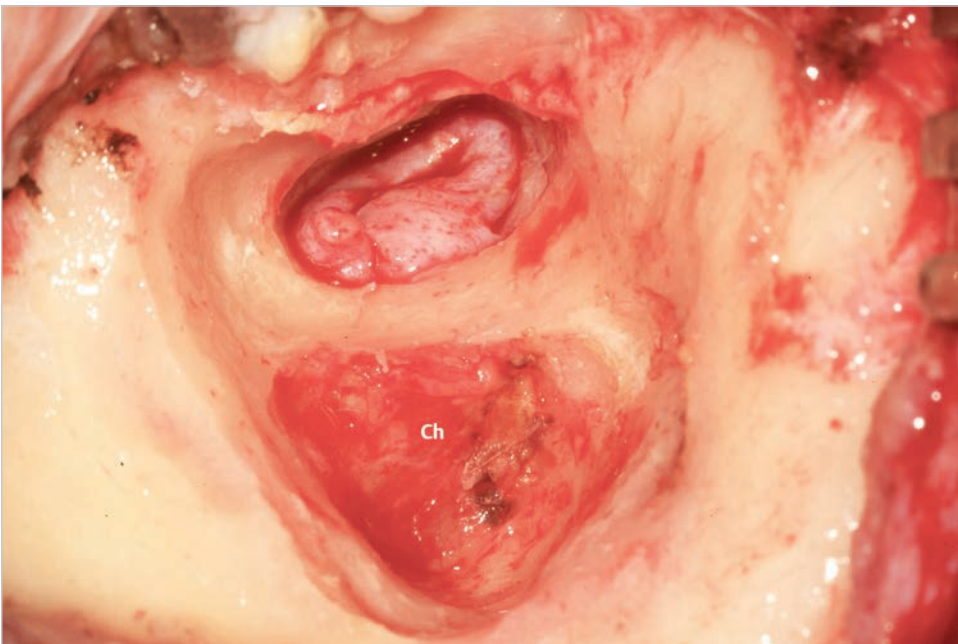


Fig. 7.171 The posterior bony wall is lowered and bony edges are removed to obtain a saucerized canal wall down cavity. Posterior end of the cholesteatoma reaching the antrum is visualized. Ch, cholesteatoma.

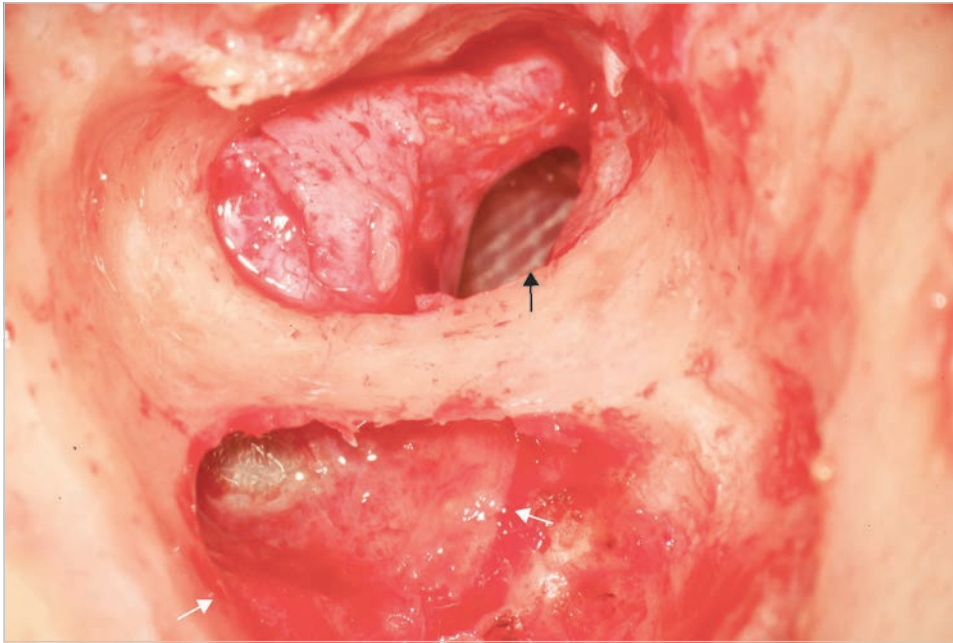


Fig. 7.172 The tympanic cavity is opened from inferior to verify absence of cholesteatoma. Silastic sheeting placed in the first-stage surgery is seen (*black arrow*). The cholesteatoma in the mastoid lined with thick cicatricial tissue (*white arrows*) is opened to visualize well the status of the medial wall of the antrum.

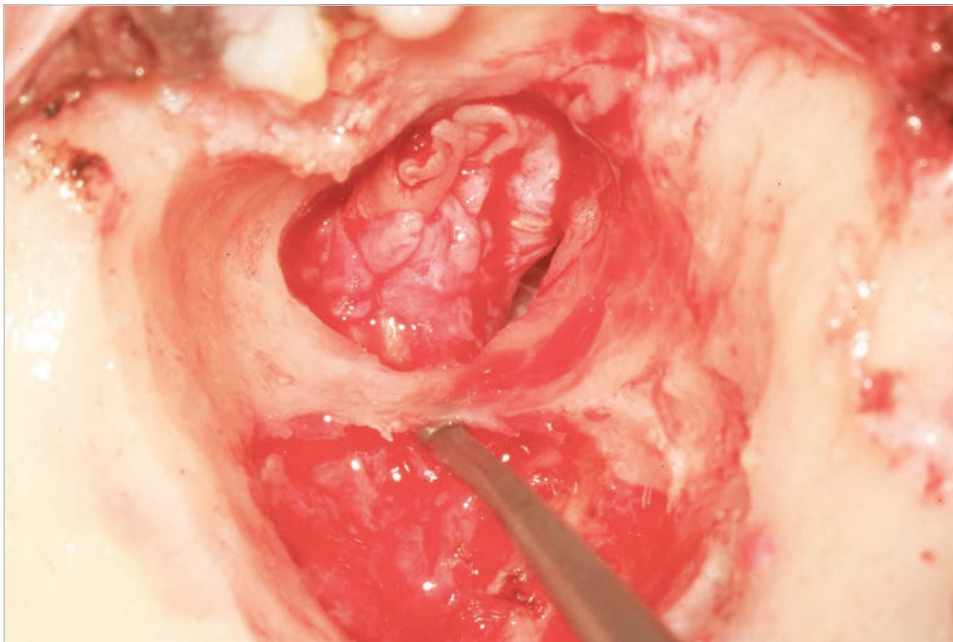


Fig. 7.173 The thinned facial bridge is removed with a curette.

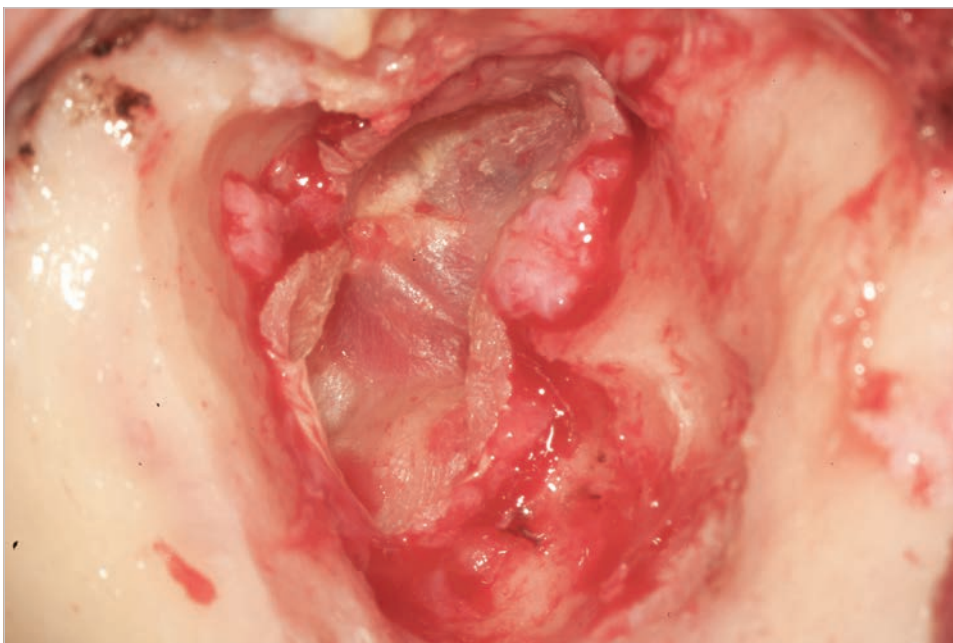


Fig. 7.174 Removal of the facial bridge visualized cholesteatoma sac in the attic and the antrum.

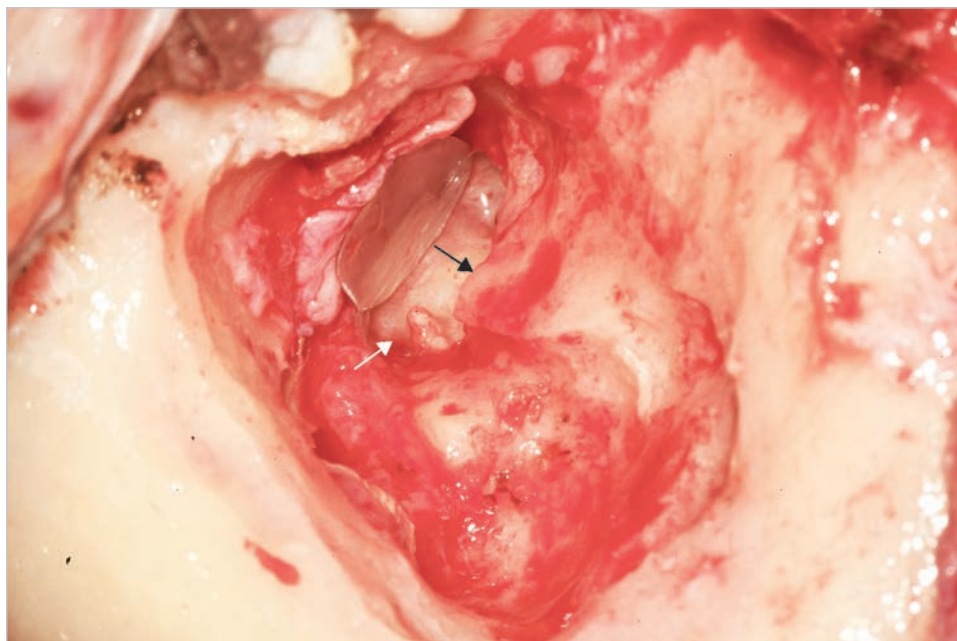


Fig. 7.175 The tympanomeatal flap is reflected anteriorly, and the tympanic cavity is opened. An aluminum sheeting holding the flap is seen. Note that condition of mucosa in the tympanic cavity including the area around the stapes (*white arrow*) is very good. The high facial ridge (*black arrow*) should be lowered to obtain round-shaped cavity.

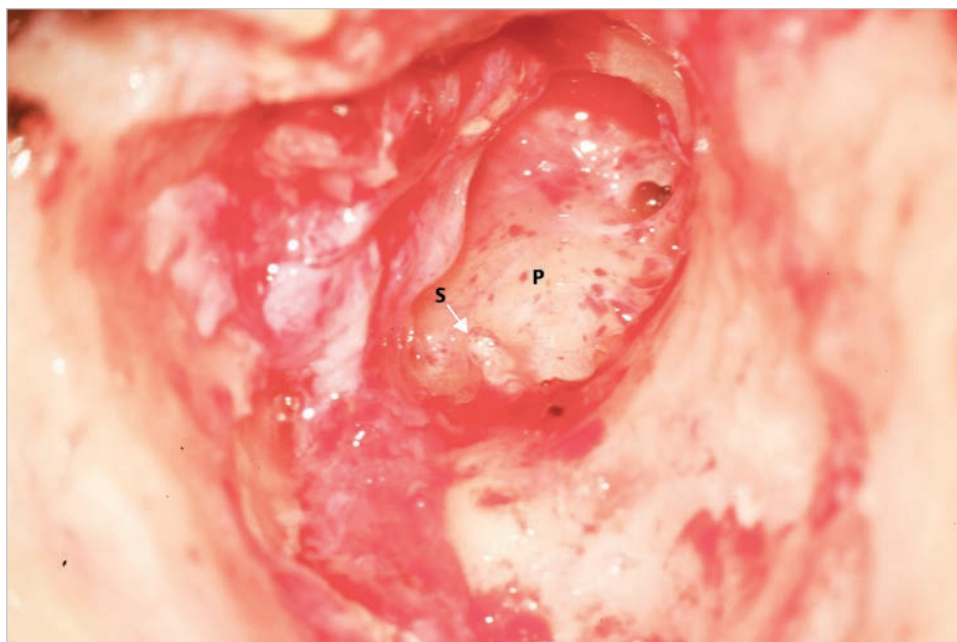


Fig. 7.176 The facial ridge is sufficiently lowered without exposing the nerve. P, promontory; S, stapes.

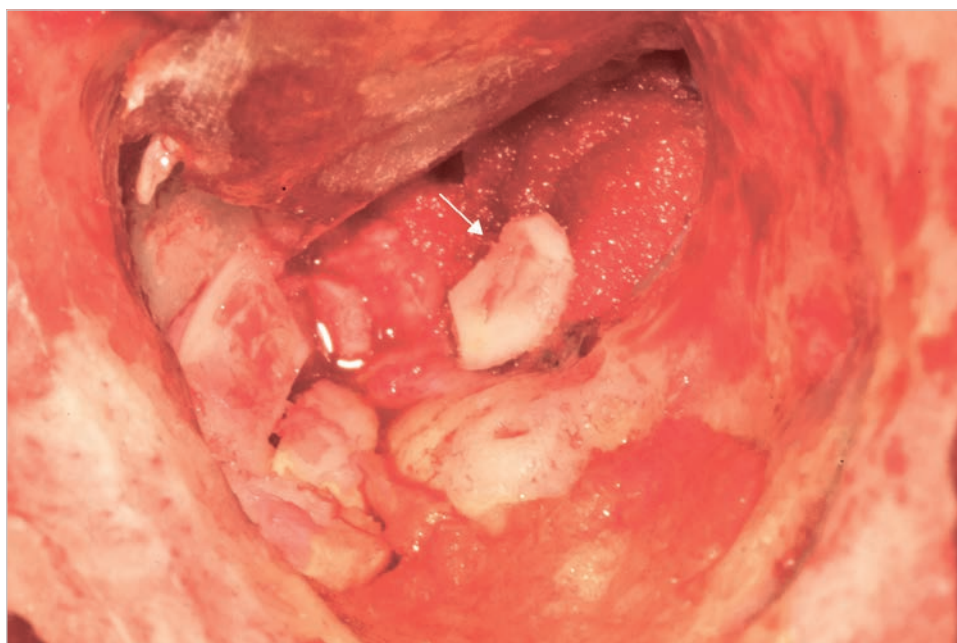


Fig. 7.177 Since mucosa in the tympanic cavity remains healthy, reconstruction of the ossicular chain is performed in the same stage. After packing the tympanic cavity with Gelfoam, a piece of cartilage (*arrow*) is placed over the head of the stapes. The attic and the antrum are partially obliterated with pieces of cartilage and bone paste.

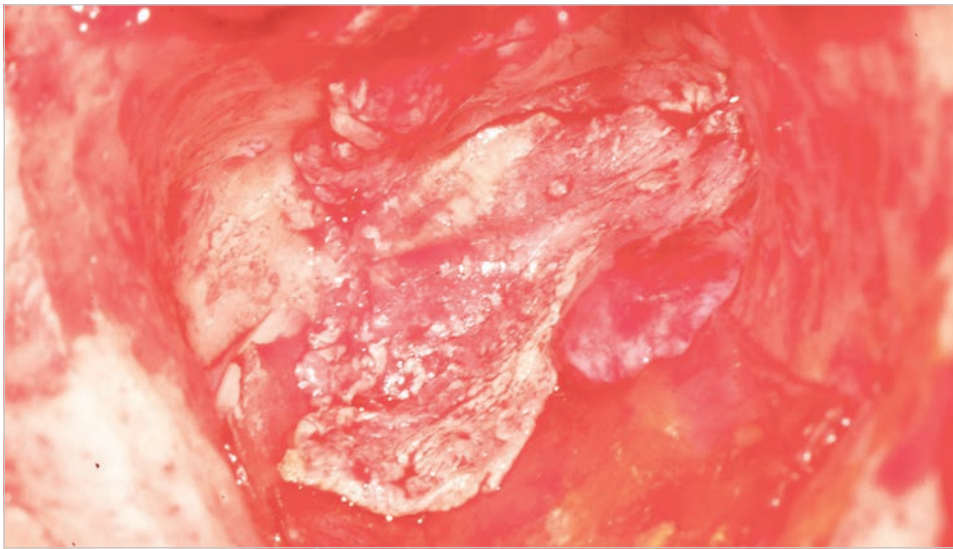


Fig. 7.178 A large piece of temporalis fascia is used to close the tympanic cavity and to cover the medial wall of the cavity. The tympanomeatal flap is replaced over the fascia.

Case 7.12 (Left Ear)

See ► Fig. 7.179, ► Fig. 7.180, ► Fig. 7.181, ► Fig. 7.182, ► Fig. 7.183, ► Fig. 7.184, ► Fig. 7.185, ► Fig. 7.186, ► Fig. 7.187, ► Fig. 7.188.



Fig. 7.179 A case of recurrent cholesteatoma in the pars flaccida. The patient underwent surgery for cholesteatoma elsewhere through transcanal approach. Progressive hearing loss with intermittent otorrhea followed. The otoscopy shows a large erosion in the pars flaccida. The incus seems absent in the attic, and the cholesteatoma descends to the mesotympanum to some extent.

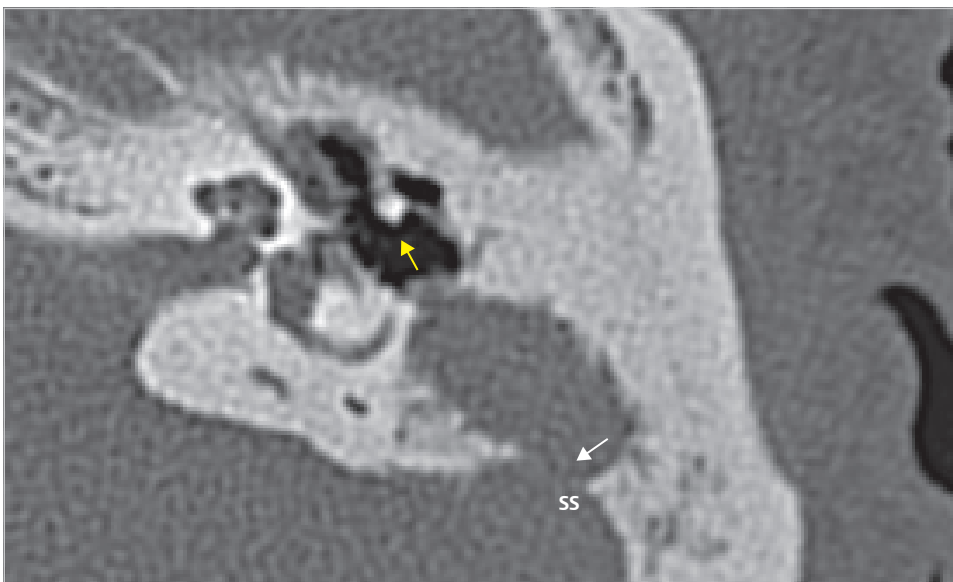


Fig. 7.180 The preoperative CT demonstrates cholesteatoma located lateral to the remnant of the malleus (yellow arrow), loss of the incus in the attic, and soft tissue density in the antrum eroding the bone covering the sigmoid sinus (white arrow). SS, sigmoid sinus.

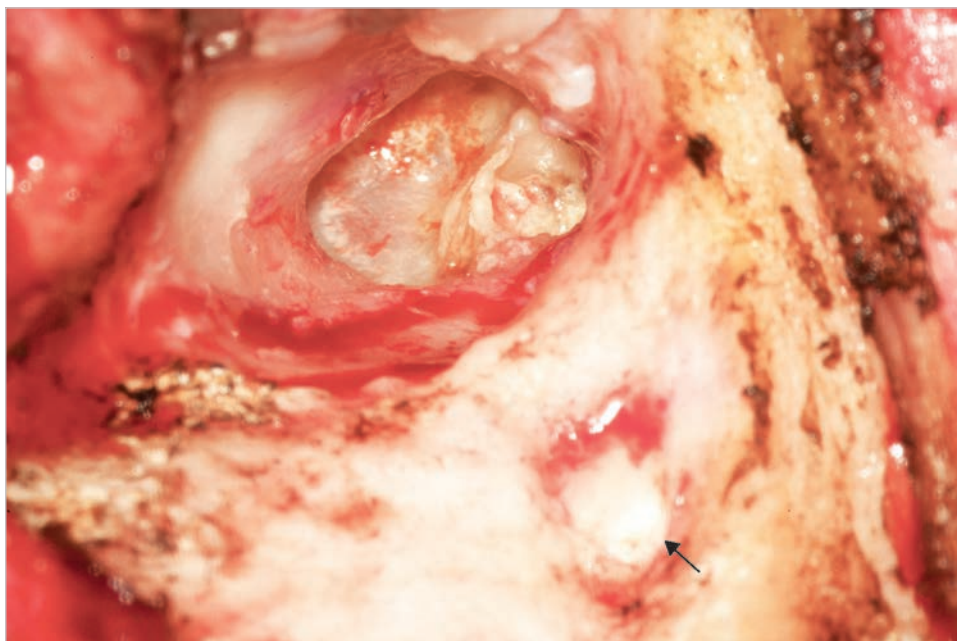


Fig. 7.181 The meatus is opened via retroauricular incision. An entrance of cholesteatoma is seen in the pars flaccida of the tympanic membrane. Removal of the cortical bone immediately exposed the cholesteatoma filling the mastoid cavity.

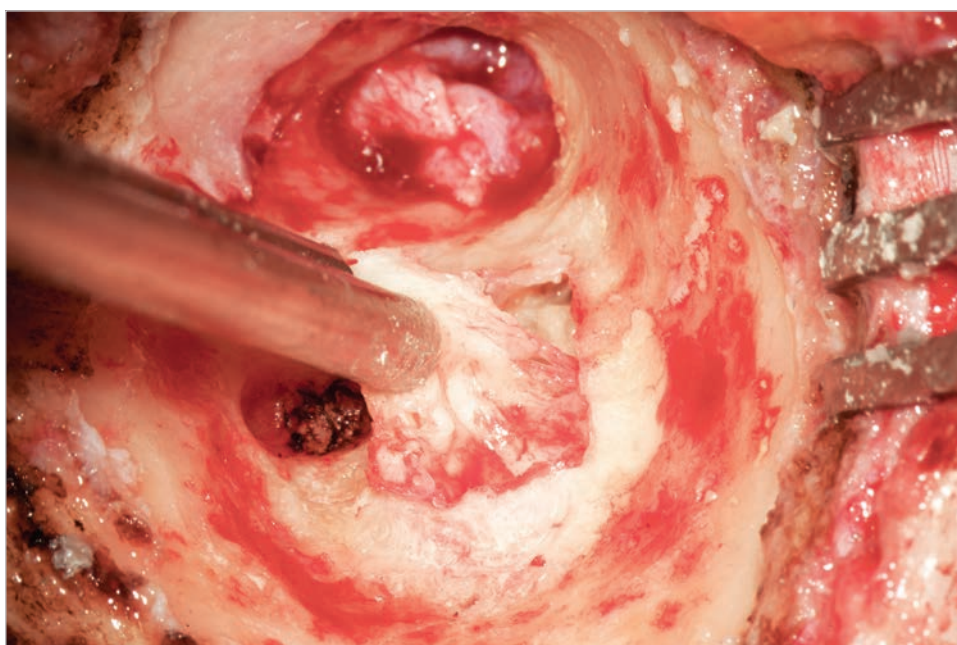


Fig. 7.182 The cholesteatoma in the mastoid is dissected.

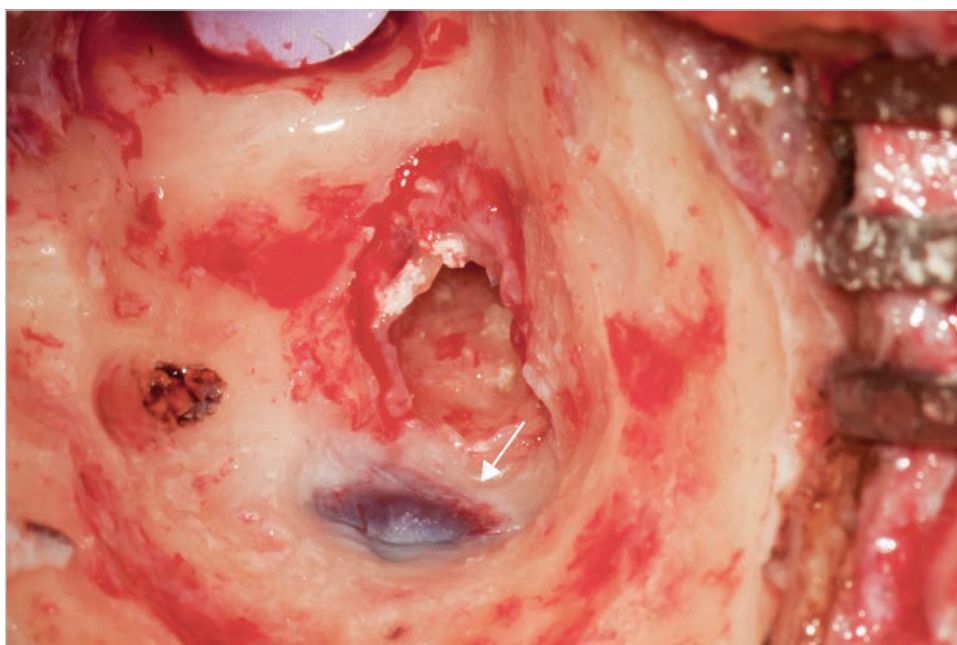


Fig. 7.183 The cholesteatoma is partially removed from the mastoid. The sigmoid sinus exposed under the matrix is seen (arrow).

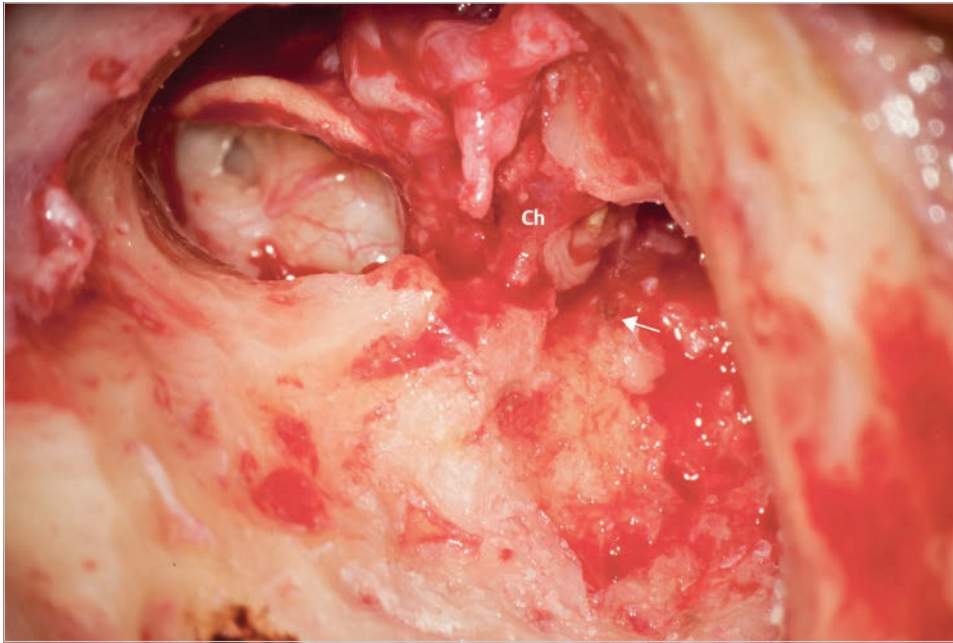


Fig. 7.184 The tympanic cavity is opened from inferior to superior. The cholesteatoma shows limited extension to the tympanic cavity, allowing clear identification of the promontory. A blue line of the lateral semicircular canal is identified at the anterior end of its bony eminence (*arrow*). Ch, cholesteatoma.

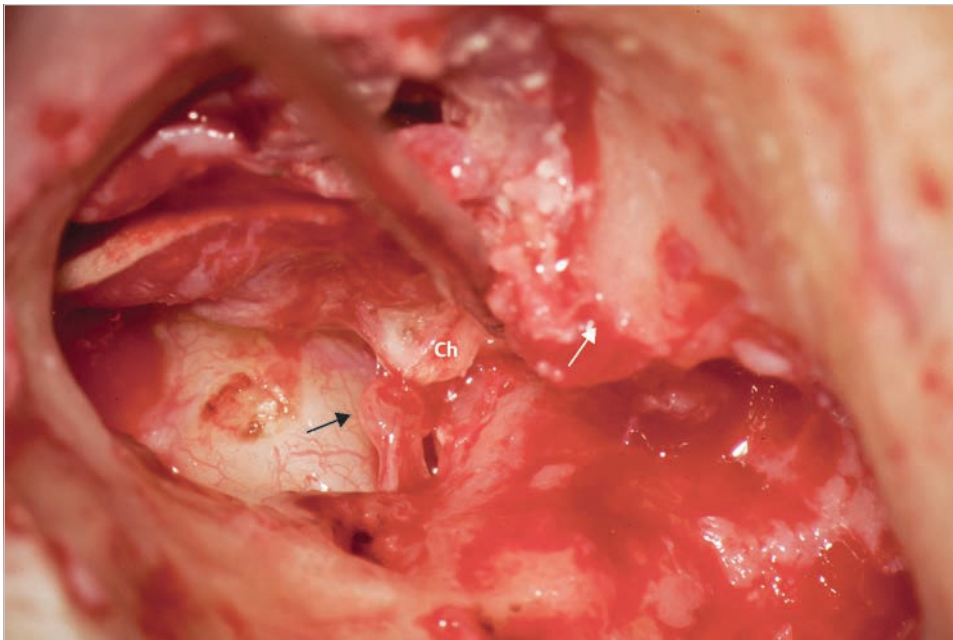


Fig. 7.185 The matrix in the posterior mesotympanum is detached from the facial nerve and the head of the stapes (*black arrow*), and reflected anteriorly. The facial nerve is uncovered superiorly to the stapes, and touches to it. The bone covering the anterior part of the attic (*white arrow*) needs to be removed. Ch, cholesteatoma.

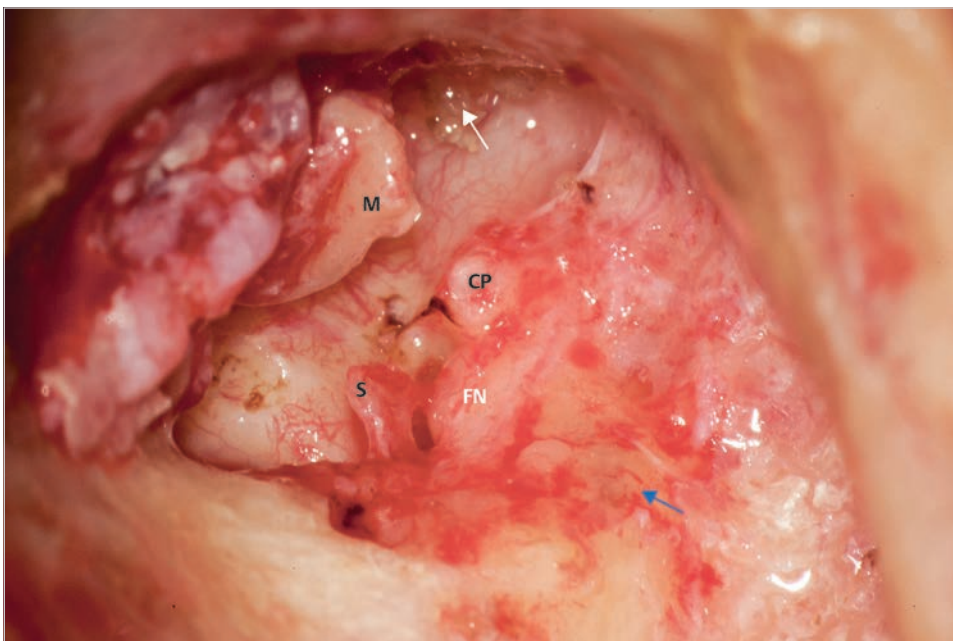


Fig. 7.186 The head of the malleus is cut, and removal of cholesteatoma is accomplished. The tympanic segment of the facial nerve protruded to touch the stapes. The supratubal recess (*white arrow*) needs to be obliterated to prevent reformation of cholesteatoma. A blue line of the lateral semicircular canal (*blue arrow*) is located just superiorly to the tympanic segment of the facial nerve. CP, cochleariform process; FN, facial nerve; M, handle of the malleus; S, stapes.

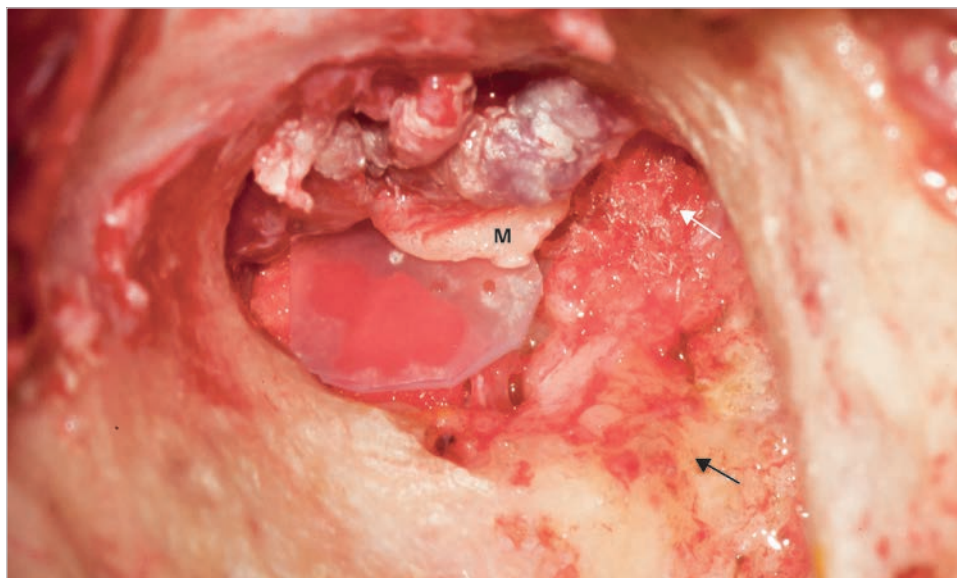


Fig. 7.187 After packing the tympanic cavity with Gelfoam, Silastic sheeting is placed in the tympanic cavity. A small piece of cottonoid (*white arrow*) is temporarily placed over the supratubal recess for hemostasis. The blue line of the lateral semicircular canal (*black arrow*) is seen. M, handle of the malleus.

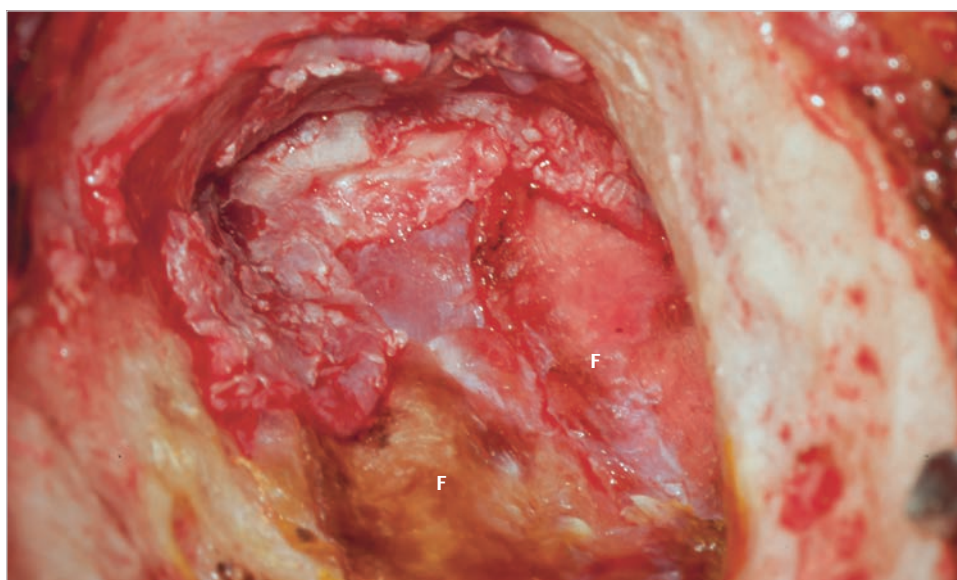


Fig. 7.188 The supratubal recess and the medial wall of the attic is obliterated with pieces of cartilage. The exposed sigmoid sinus is covered with bone paste. Two pieces of fascia are used to cover the medial wall of the cavity, and the tympanomeatal flap is replaced over the fascia. F, fascia.

Case 7.13 (Right Ear)

See ► Fig. 7.189, ► Fig. 7.190, ► Fig. 7.191, ► Fig. 7.192, ► Fig. 7.193, ► Fig. 7.194, ► Fig. 7.195, ► Fig. 7.196, ► Fig. 7.197, ► Fig. 7.198, ► Fig. 7.199, ► Fig. 7.200.

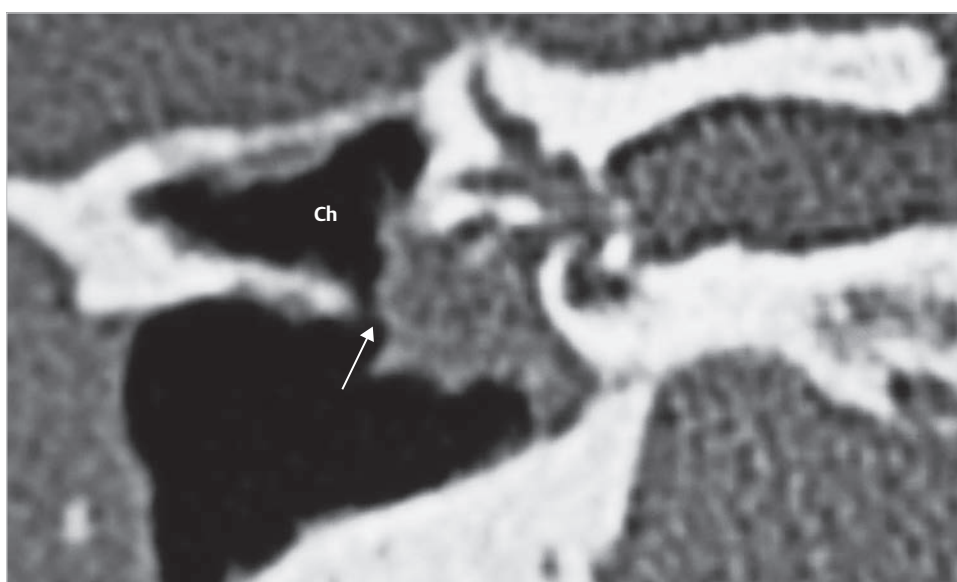


Fig. 7.189 A case of recurrent cholesteatoma after canal wall up tympanoplasty performed elsewhere. The preoperative CT demonstrates destruction of bony wall (*arrow*) and accumulation of debris over the posterosuperior quadrant of the tympanic membrane. No aeration is seen in the tympanic cavity. Ch, cholesteatoma.



Fig. 7.190 According to our therapeutic strategy, reformation of cholesteatoma is one of absolute indications to remove the posterior wall. The cholesteatoma entered the mastoid through a large erosion in the posterior wall (arrow).



Fig. 7.191 The middle fossa plate and the sigmoid sinus are identified. A large erosion of the posterior bony wall is visualized. MFP, middle fossa plate; SS, sigmoid sinus.

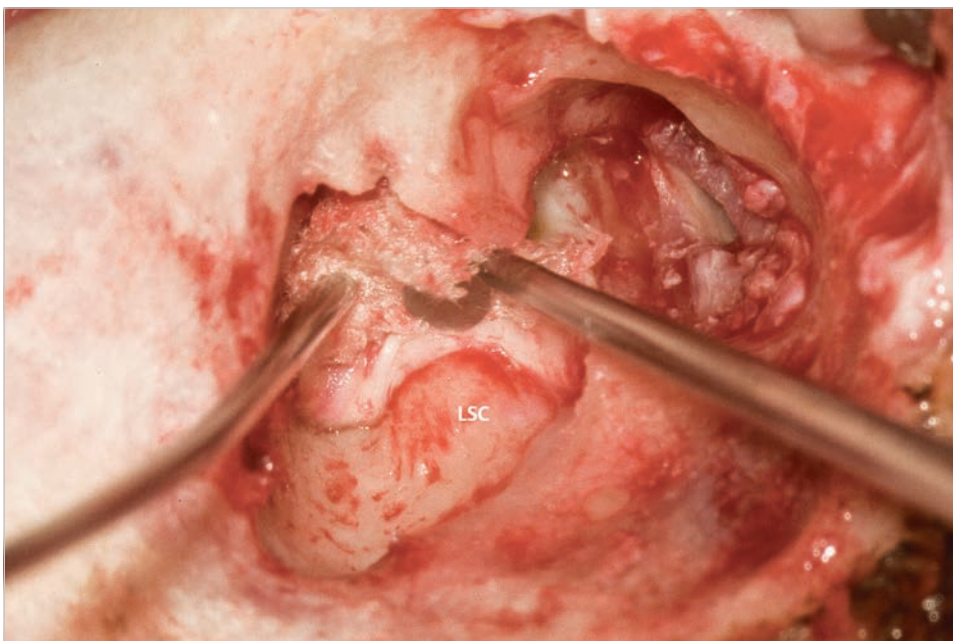


Fig. 7.192 The cholesteatoma is dissected from the antrum with the help of cottonoid. The eminence of the lateral semicircular canal is started to be visualized. LSC, lateral semicircular canal.

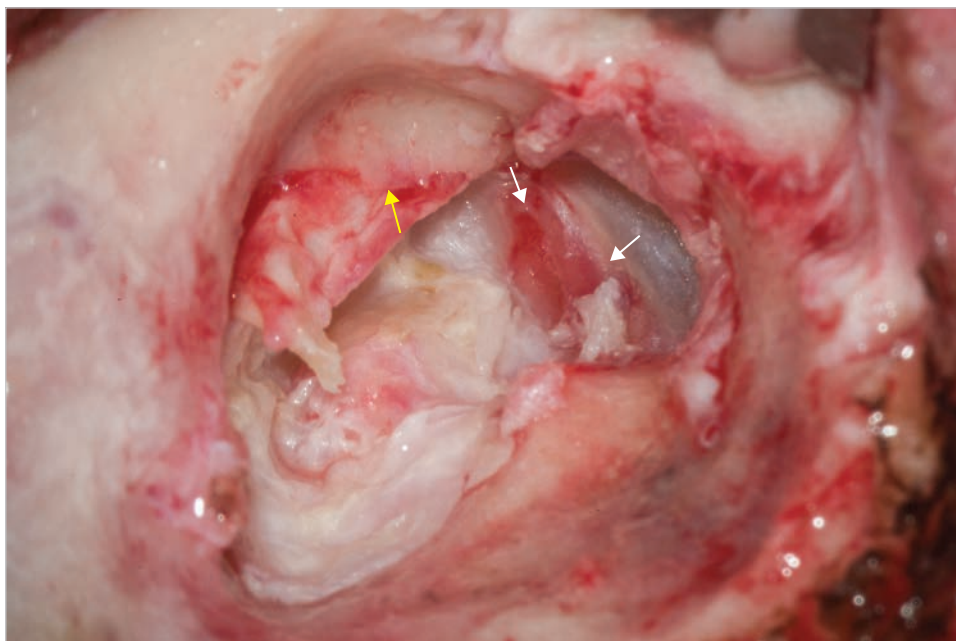


Fig. 7.193 The majority of the debris filling the cholesteatoma is evacuated. Note that the tympanic membrane is inflamed and adherent to the medial wall of the tympanic cavity (*white arrows*). The bony (*yellow arrow*) covering the anterior attic should be removed.

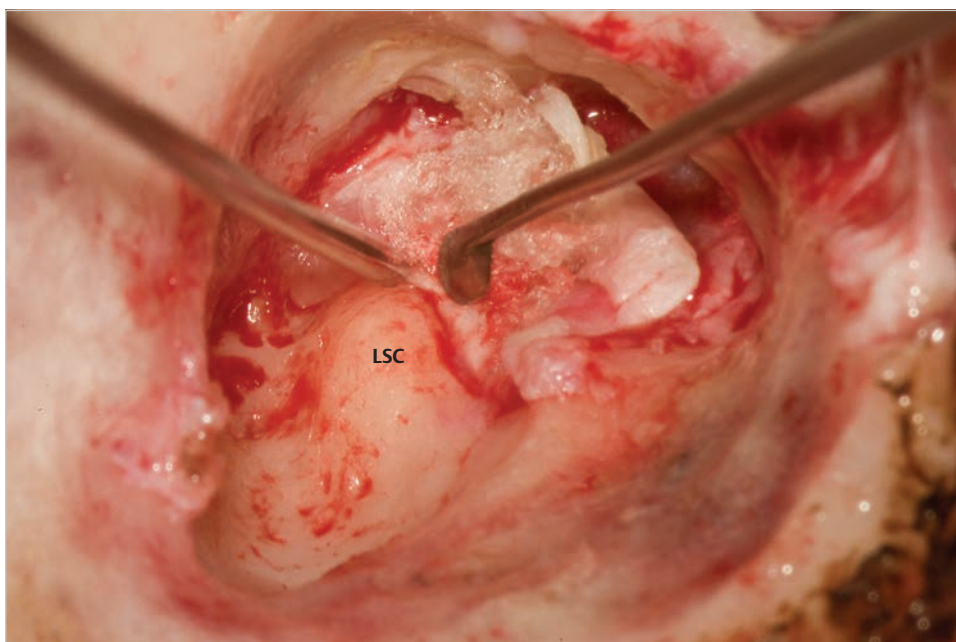


Fig. 7.194 With the help of cottonoid, dissection of the matrix is proceeded toward the mesotympanum to reach the area of the facial nerve. LSC, lateral semicircular canal.

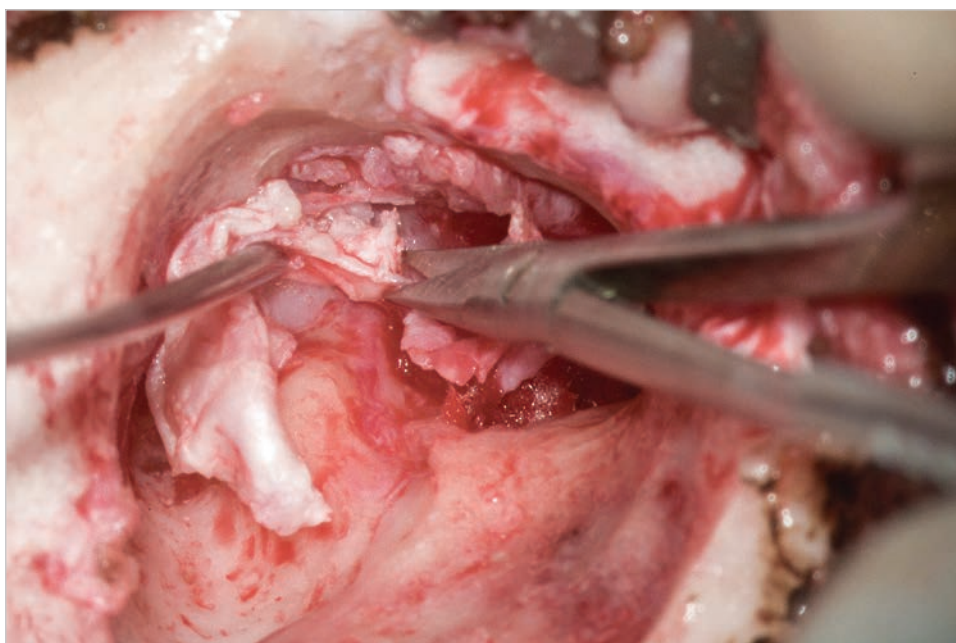


Fig. 7.195 The matrix is cut away from time to time for better visualization of structures in the middle ear.

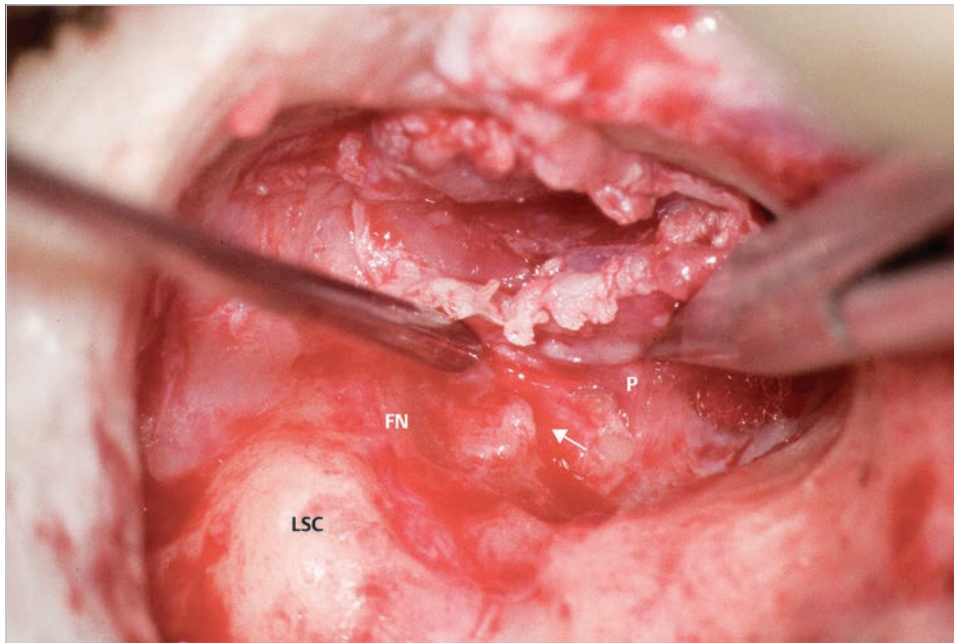


Fig. 7.196 The tympanic membrane adherent to the medial wall of the tympanic cavity is carefully dissected toward the eustachian tube. The stapes (*arrow*) can be identified between the facial nerve and the promontory. FN, facial nerve; LSC, lateral semicircular canal; P, promontory.



Fig. 7.197 Dissection of the tympanic membrane is accomplished and the eustachian tube (*arrow*) is opened.

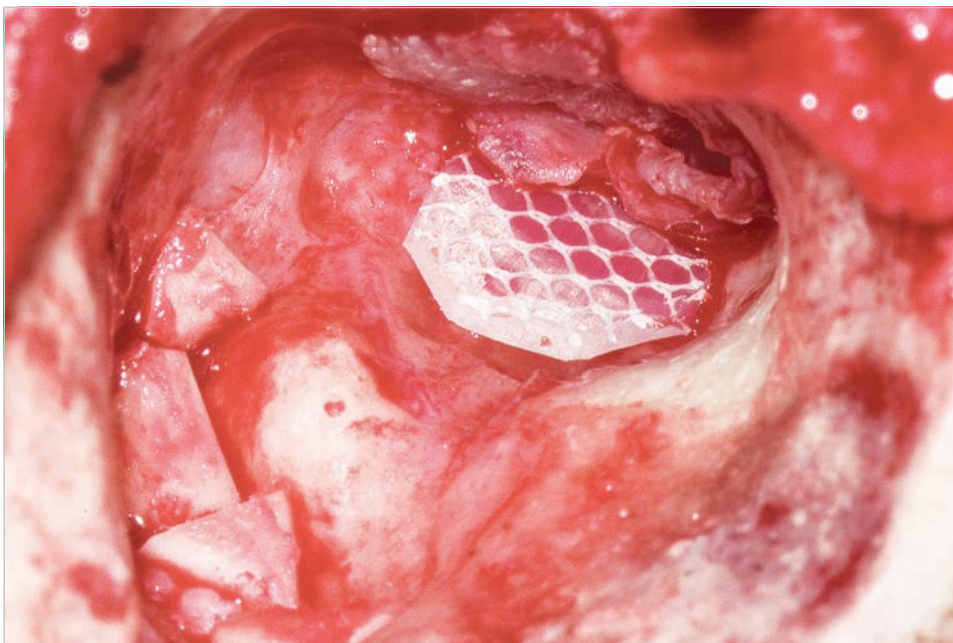


Fig. 7.198 A piece of Silastic sheeting is placed to prevent readhesion of the tympanic membrane. Dips in the medial wall of the attic and in perilyabyrinthine area are obliterated with pieces of cartilage.



Fig. 7.199 A large piece of temporalis fascia is placed to reconstruct the tympanic cavity, and to cover the medial wall of the mastoid at the same time. The tympanomeatal flap is replaced over it.



Fig. 7.200 The second-stage surgery is carried out to remove Silastic sheeting and to place a large piece of cartilage over the stapes. The otoscopy shows self-cleansing round-shaped cavity. Cartilage used in the first-stage for partial obliteration can be seen in the mastoid.

Case 7.14 (Right Ear)

See ► Fig. 7.201, ► Fig. 7.202, ► Fig. 7.203, ► Fig. 7.204, ► Fig. 7.205, ► Fig. 7.206, ► Fig. 7.207, ► Fig. 7.208, ► Fig. 7.209, ► Fig. 7.210, ► Fig. 7.211, ► Fig. 7.212, ► Fig. 7.213.

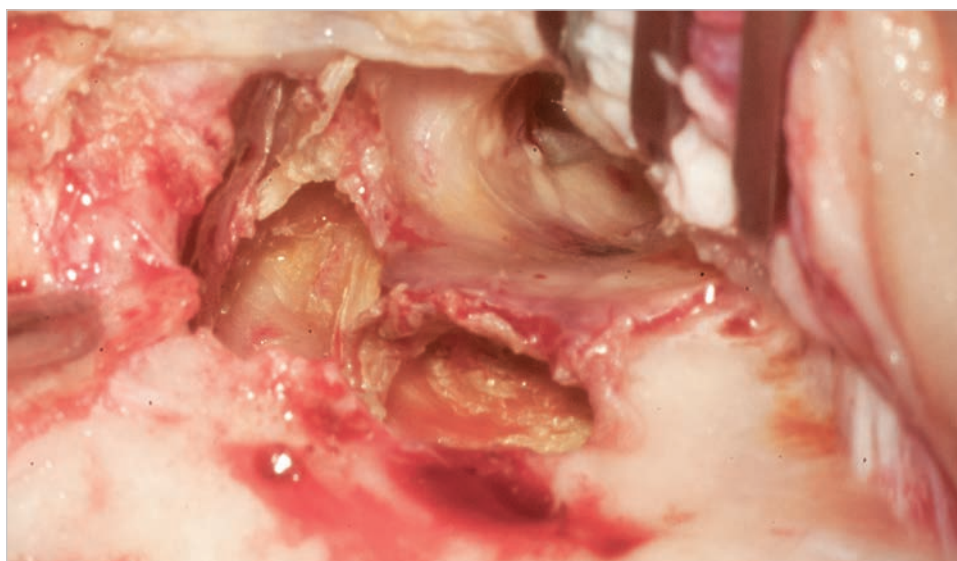


Fig. 7.201 A case of recurrent cholesteatoma in canal wall up cavity. The cholesteatoma matrix totally invaginating into the mastoid cavity drilled in the former surgery is seen.

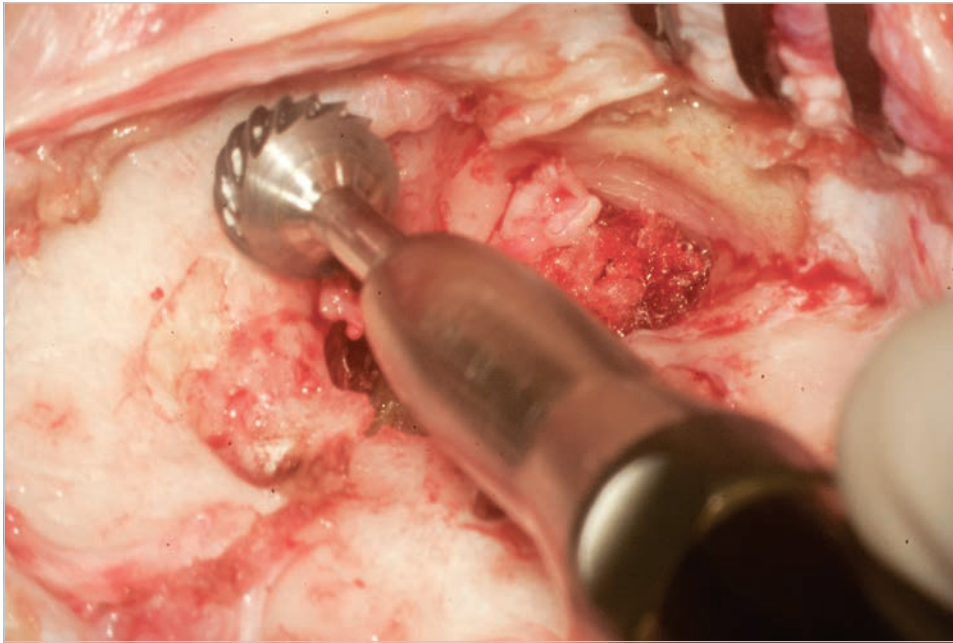


Fig. 7.202 Drilling of the mastoid is started from the lateral face with a large cutting burr. For safe surgery, it is very important not to go directly to the area of the cholesteatoma, but to saucerize the cavity first.

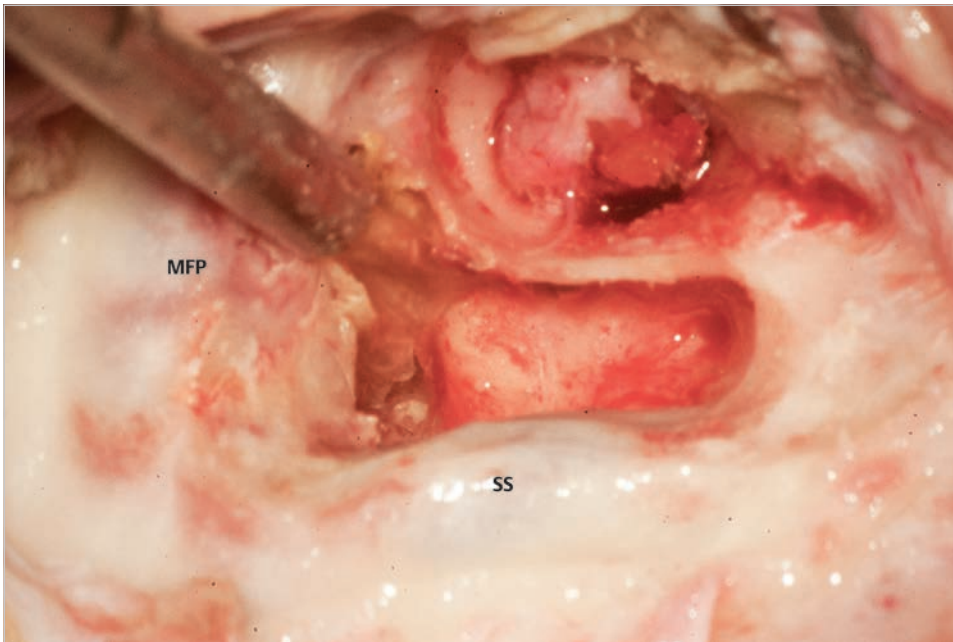


Fig. 7.203 The middle fossa plate is identified superiorly, and the sigmoid sinus is identified posteriorly. MFP, middle fossa plate; SS, sigmoid sinus.

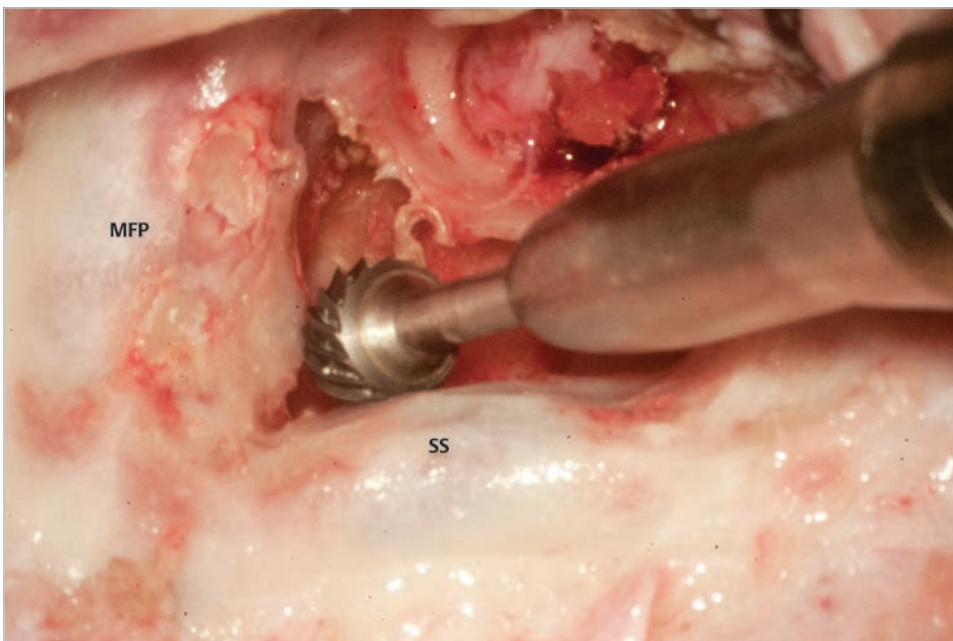


Fig. 7.204 The sigmoid sinus is identified posteriorly, and the sigmoid sinus is identified posteriorly using a large cutting burr. Cholesteatoma matrix covering the middle fossa dura is seen (arrows). The bone in the sinodural angle and covering the middle fossa plate should be opened. MFP, middle fossa plate; SS, sigmoid sinus.

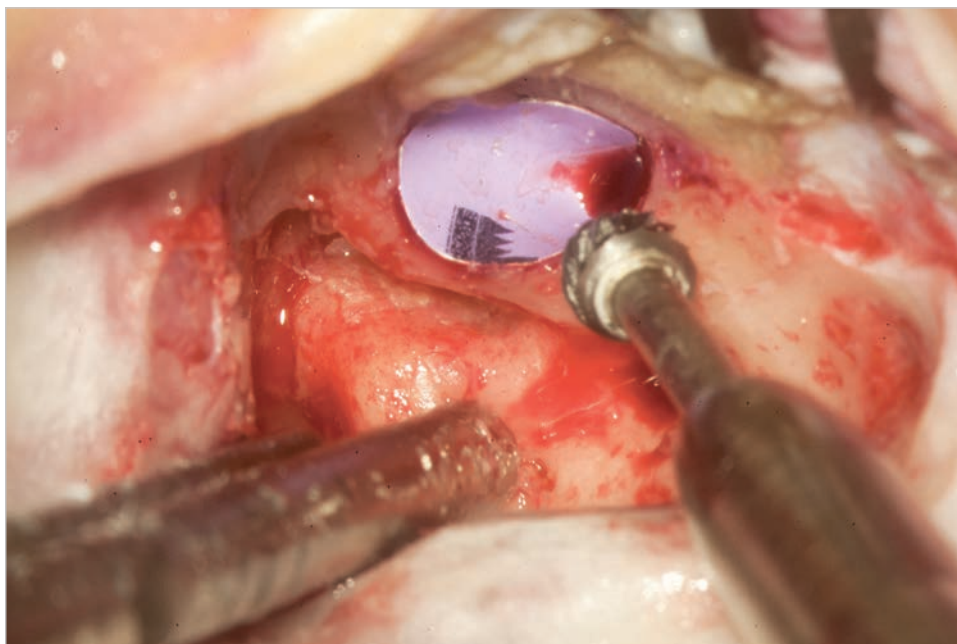


Fig. 7.205 The posterior meatal wall is removed with a cutting burr. The tympanomeatal flap is protected by aluminum sheeting.

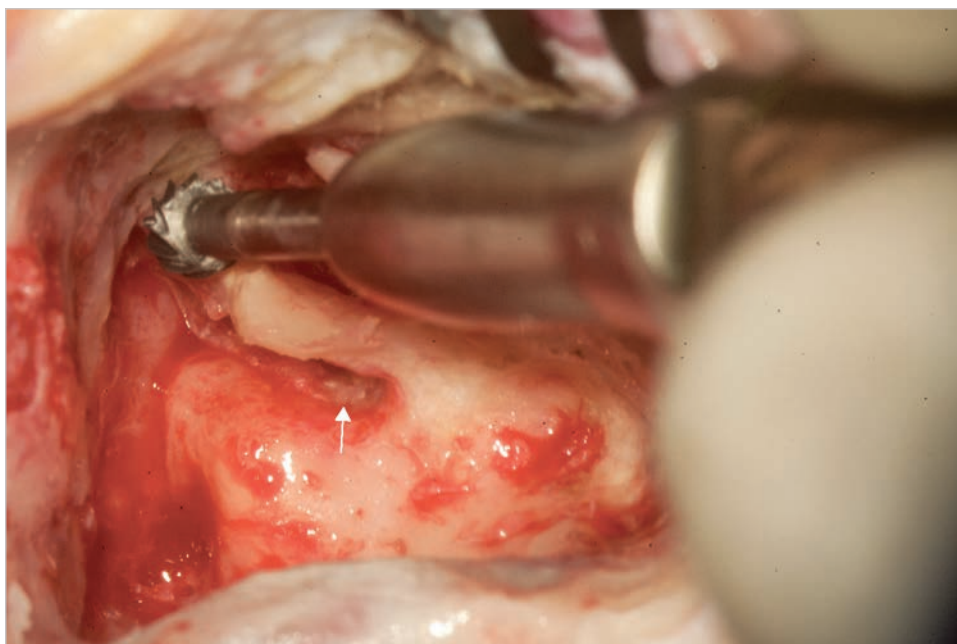


Fig. 7.206 Drilling of the bony meatal wall is advanced anteriorly to open anterior part of the attic. Cholesteatoma descends to the tympanic cavity. The posterior tympanotomy made in the former surgery is also covered with the matrix (*arrow*).

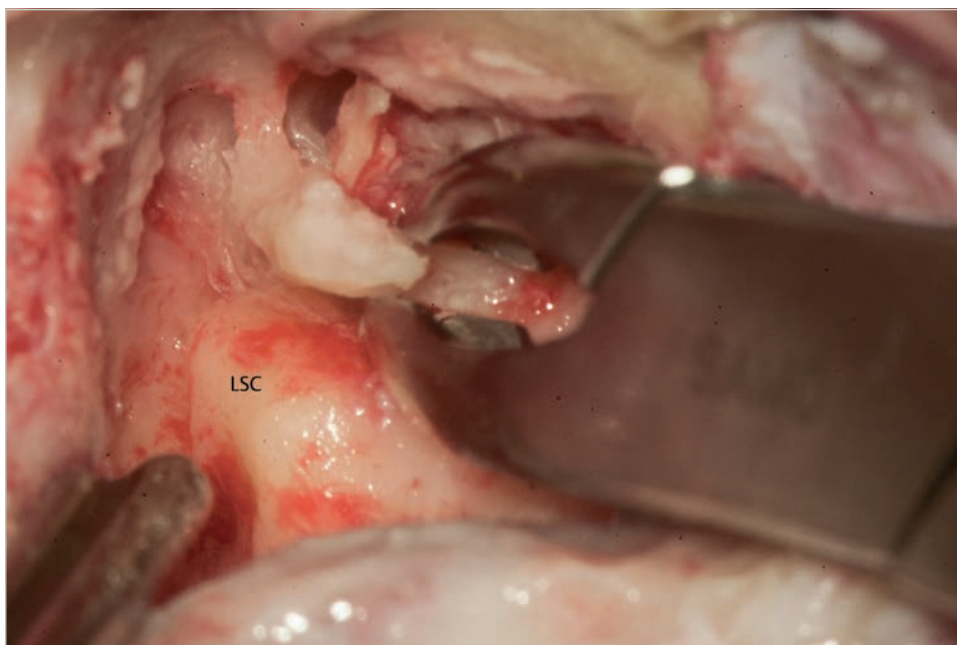


Fig. 7.207 The anterior part of the attic covered with cholesteatoma matrix is opened. Use of a rongeur to remove reduced posterior wall is time-saving procedure. LSC, lateral semicircular canal.



Fig. 7.208 The entrance of cholesteatoma is opened. Note that the cholesteatoma descends toward the tympanic cavity, and covers a remnant of the malleus head. M, head of malleus.

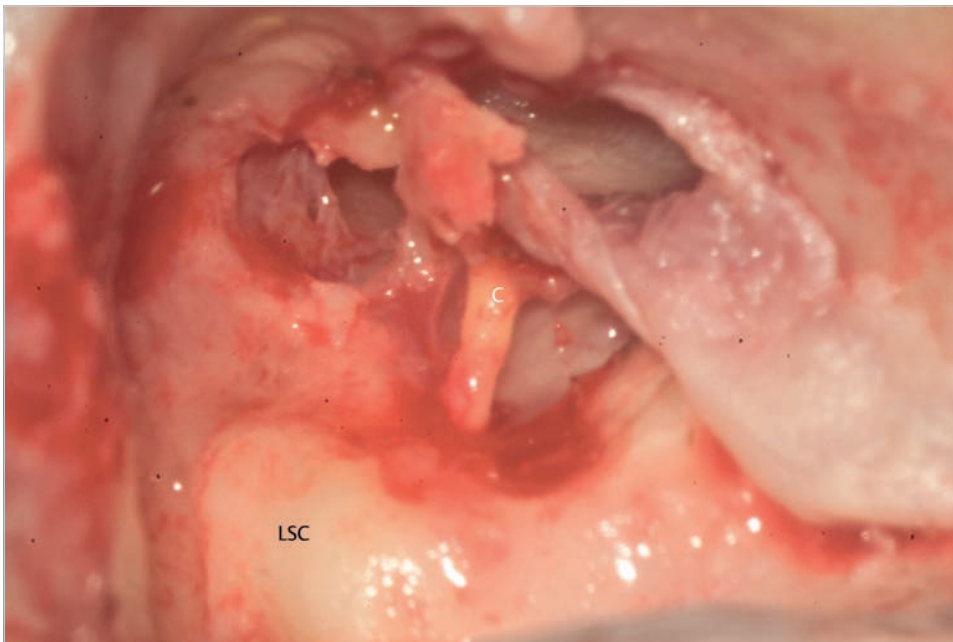


Fig. 7.209 The cholesteatoma matrix descending to the mesotympanum is removed to expose the columella (total ossicular replacement prosthesis [TORP]) placed in the former surgery over the oval window. The tendon of the tensor tympani muscle is cut to open the tympanic cavity fully. Note that the TORP is too long for the canal wall down cavity. C, columella; LSC, lateral semicircular canal.

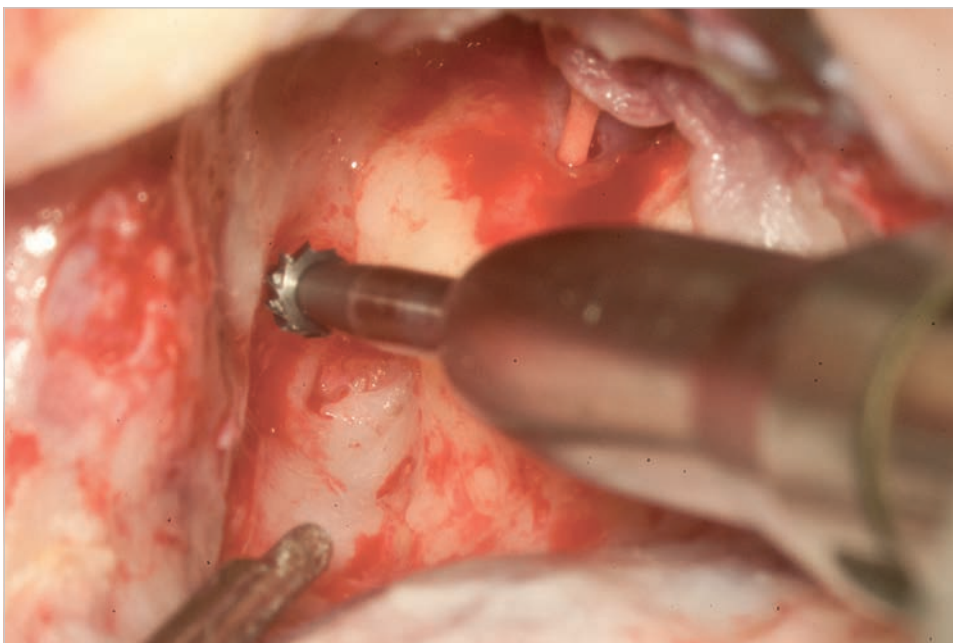


Fig. 7.210 The perilabyrinthine cells should be removed with cutting burrs if there is any concern of residual cholesteatoma. Use of diamond burrs is prohibited since it may bury cholesteatoma matrix under bone dust.

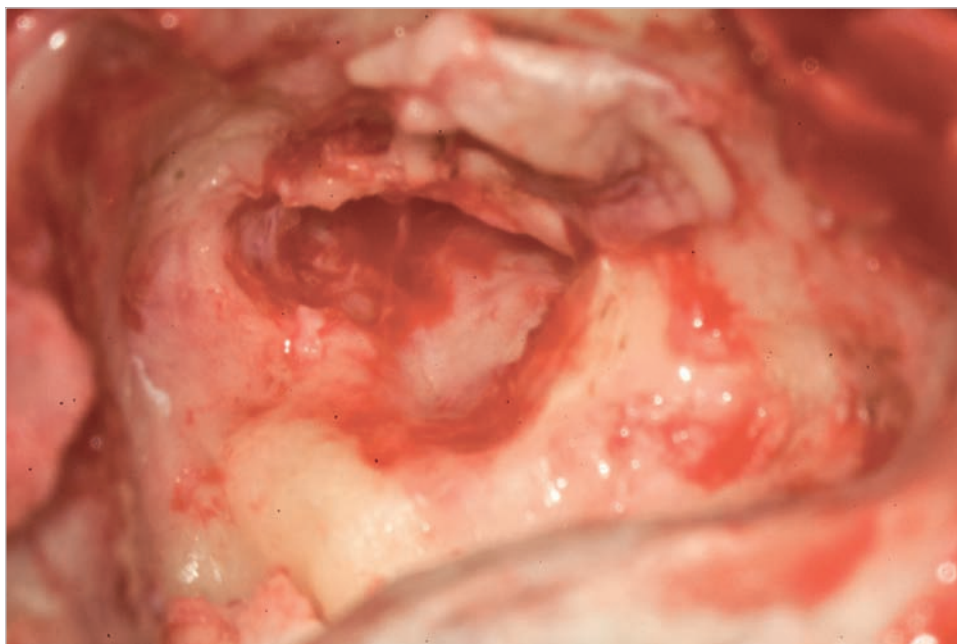


Fig. 7.211 The cholesteatoma is eradicated from the middle ear. Note that the facial ridge is sufficiently lowered, and the cavity is rounded.

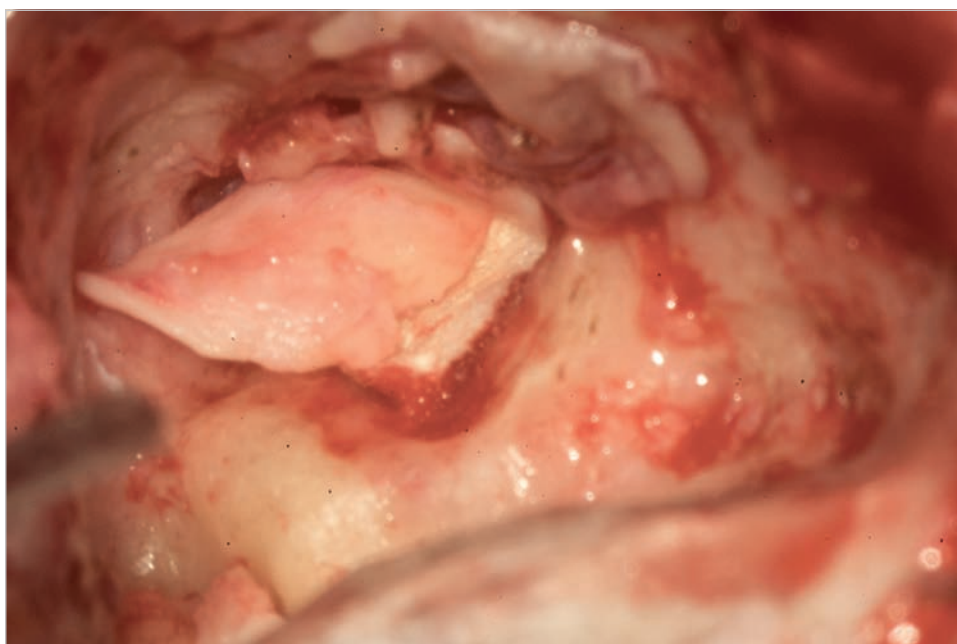


Fig. 7.212 A Silastic sheeting is placed in the tympanic cavity and a large piece of tragal cartilage is placed over it to prevent retraction of the tympanic membrane.



Fig. 7.213 The cartilage is covered with a large piece of temporalis fascia.

7.1.5 Hints and Pitfalls of Canal Wall Down Tympanoplasty

- There is no single technique for every cholesteatoma. Individualized treatments must be adopted in general rules.
- All the procedures should be in the storehouse of the skilled surgeon.
- Decision making on surgery is mainly based on pathology, and a CWD technique is generally planned before surgery in cases of cholesteatoma.
- A wet and draining cavity that requires frequent and continuous office visit is not the fault of CWD technique itself, but fault of the surgeon.
- Correctly performed CWD technique together with sufficiently large meatoplasty is the prerequisite for obtaining a self-cleaning dry cavity.
- Do not leave any bony overhang in the edge of the cavity. The bony edges must be removed and rounded as much as possible, to obtain a saucerized cavity.
- Thin sufficiently the middle fossa plate and the sigmoid sinus plate, but do not expose them. Open widely the sinodural angle.
- A deep, pneumatized mastoid tip must be lowered and removed.
- Rarely, the posteroinferiorly based soft tissue flap is used to obliterate the area of the mastoid tip if a deep dip remains after these procedures.
- The facial ridge must be lowered sufficiently.
- Spaces that may become aerated dip, especially retrofacial cells, are obliterated with autologous cartilage and/or bone paté.
- Suspect always a labyrinthine fistula. Over 10% of our cases with cholesteatoma are complicated by this condition.
- Always pay attention to the facial nerve and its anatomical landmarks. Important landmark for lowering the facial ridge at the level of the antrum is the prominence of the lateral semicircular canal. The second genu of the nerve is located inferomedial to the prominence.
- Patients usually complain some discomfort when the chorda tympani nerve is insulted under local anesthesia.
- Drilling over the mastoid segment of the facial nerve must be carried out with large burrs, and always with continuous suction irrigation. The burrs should be moved parallel to the nerve.
- Anterior buttress must be removed. Leaving the buttress in place may facilitate ingrown skin under it.
- Perilabyrinthine cells in the attic must be drilled out. Care should be taken not to damage the superior semicircular canal and the labyrinthine segment of the facial nerve located medially to the geniculate ganglion.
- Very good and reliable landmarks for the tympanic segment of the facial nerve are the cochleariform process and the cog.
- Ossiculoplasty may be performed in the same stage if required. However, staged surgery is preferable.
- Meatoplasty is of paramount importance. Absence of this step will give an insufficient aeration of the cavity with all the cavity problems.
- Do not leave the edge of the conchal cartilage uncovered. This may produce a very painful postoperative complication, namely, auricular perichondritis.

7.2 Modified Bondy Technique

Some patients with cholesteatoma maintain good or better hearing in the diseased ear and hearing preservation is of first importance. Closed tympanoplasty may give a chance to maintain hearing. However, if the ossicular chain is reconstructed, preservation of normal or good preoperative hearing is not always possible, and the second operation may carry an additional risk to the hearing.

In modified Bondy technique, the posterior canal wall is removed, but the articulations between the ossicles are not touched. The prerequisite conditions for using this technique are an intact ossicular chain and the tympanic membrane with cholesteatoma located laterally to the chain, usually epitympanic cholesteatoma (►Fig. 7.214). A contracted mastoid is preferred. Significant benefits of this technique are constant and long-lasting preservation of preoperative hearing (►Table 7.1) as a result of preserved ossicular articulations, low rate of residues compared to closed technique (►Table 7.2), and that is a one-stage operation that does not necessitate a second intervention.

The risk of this procedure is sensorineural hearing loss at the high frequencies due to acoustic trauma, especially when drilling around the chain, since the ossicular chain remains intact throughout the surgery. Drilling around the chain should be conducted correctly and meticulously. With appropriate selection of cases, there are no further disadvantages compared with other open mastoidectomy procedures.

Indications

- Epitympanic cholesteatoma in normal or good hearing ear with an intact tympanic membrane, ossicular chain, and the tympanic cavity.
- Epitympanic cholesteatoma in the better or only hearing ear with slightly insulted ossicular chain.
- Some cases of bilateral postinflammatory canal stenosis.

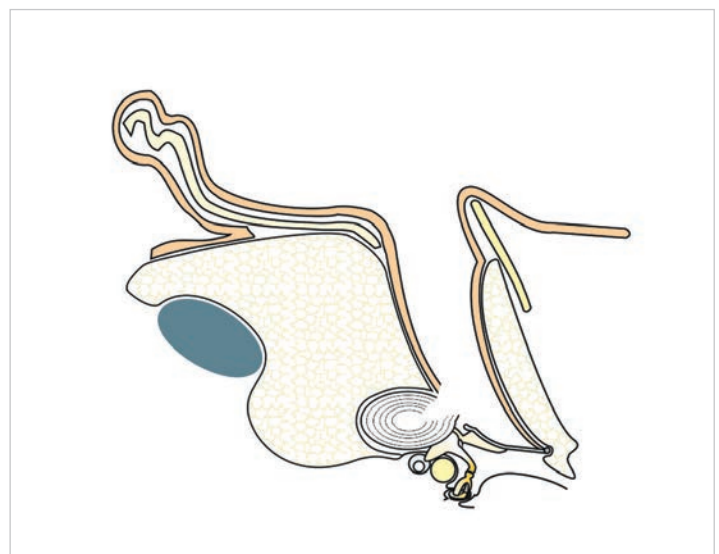


Fig. 7.214 Indication for modified Bondy technique.

Table 7.1 Hearing outcomes of 303 patients operated with modified Bondy technique at Gruppo Otologico. The pure tone average (PTA) is noted for air conduction (AC) and bone conduction (BC) as the mean of 500, 1,000, 2,000, and 4,000 Hz.

Hearing outcomes	Preop (dB)	Postop (dB)	
		First year	Fifth year
PTA AC	30 ± 12	31 ± 12	31 ± 12
PTA BC	16 ± 8	17 ± 8	17 ± 8
A-B gap	14 ± 7	14 ± 7	14 ± 8

Table 7.2 Postoperative sequelae of 303 patients operated with modified Bondy technique at Gruppo Otologico after 5-year follow-up.

Sequelae		Patients (%)
Recurrence		
Residual	Lateral to tympanic membrane	8.1
	Medial to tympanic membrane	0
Reformation		0
Effusion		5
Retraction pocket		3.1
Discharging ear		1.5
Perforation		1.5
Meatal stenosis		1.2

7.2.1 Surgical Steps

1. A mastoidectomy is completed with one of two techniques described earlier. Sufficient lowering of the facial ridge to the level of the tympanic annulus is of tremendous importance. The drill should be moved parallel to the nerve during this procedure.
2. A highly pneumatized mastoid tip should be amputated as described previously. Extensive pneumatization in the cavity are filled with cartilage and/or bone paste.
3. In transcortical mastoidectomy, posterior epitympanotomy is performed taking care not to touch the intact ossicular chain. The bed should be tilted away from the surgeon to help identify the chain as soon as possible. The burr should be moved from an area near the ossicles to elsewhere, but never toward the ossicles.
4. If canalplasty is required, the anterior meatal skin is cut and folded medially. The inferior canal wall is widened to get a round cavity. The tympanomeatal flap should be protected with a thin aluminum sheet during the drilling.
5. The facial bridge is removed with a curette, taking special care not to injure the chain. Burrs may be used, but since the ossicular chain remains intact, this might carry more risks. The anterior and the posterior buttresses are also removed in the same way. The anterior epitympanum should fully be opened. The facial ridge is further lowered.
6. Cholesteatoma is removed from the attic and the mastoid. The posterosuperior annulus is partially detached from the tympanic sulcus, and the tympanic cavity is carefully inspected to ensure absence of cholesteatoma. Pathological tissue, such as scar and granulation tissue, if any, is dissected with meticulous care from the ossicular chain. Minor invagination of cholesteatoma matrix behind the body of incus and/or head of the malleus is carefully dissected from the chain.
7. In limited cases, moderate extension of cholesteatoma medially to the ossicular chain can be removed without insulting the chain. Removal of the posterior wall gives wider access comparing to CWU technique, giving better chance to dissect

- cholesteatoma located medially to the chain. In such cases, the tegmen of the mastoid and the attic are thinned, the fossa incudis is fully opened, and/or the lateral wall of the supratubal recess is removed sufficiently depending on the location of the disease.
8. Meatoplasty is performed to obtain sufficiently large access to the cavity postoperatively. The conchal cartilage is harvested for the subsequent reconstruction.
 9. A piece of cartilage is placed in the attic, medially to the body of the incus and the head of the malleus (► Fig. 7.215). This cartilage prevents retraction of the reconstructed tympanic membrane behind the ossicles. Bone paste should not be used in this area to avoid fixation of the ossicular chain. The eustachian tube and the tympanic cavity are packed with Gelfoam.
 10. A longitudinal cut is made in the temporalis fascia. One tongue is placed medial to the body of the incus and the head of the malleus, extending anteriorly under the anterosuperior quadrant of the tympanic membrane. The other tongue is inserted lateral to the long process of the incus and medial to the handle of the malleus making the fascia underlay (► Fig. 7.215, ► Fig. 7.216). In some cases, a thin piece of cartilage may be inserted over the long process of the incus to avoid retraction of the posterosuperior quadrant (► Fig. 7.217).
 11. As large an exposed bony surface as possible is covered with the posterior extension of the fascia. Another piece of fascia may be placed to cover exposed bone and materials used for obliteration. The tympanomeatal flap is replaced on the temporalis fascia (► Fig. 7.217). The sequence of tympanic membrane reconstruction is shown in ► Fig. 7.218, ► Fig. 7.219, ► Fig. 7.220, ► Fig. 7.221.
 12. If the ossicular chain is substantially involved in the cholesteatoma and its dissection is difficult, it is necessary to remove the body of the incus with/without the head of the malleus. This converts the technique to CWD (open) tympanoplasty. The chain may be reconstructed in the same stage.

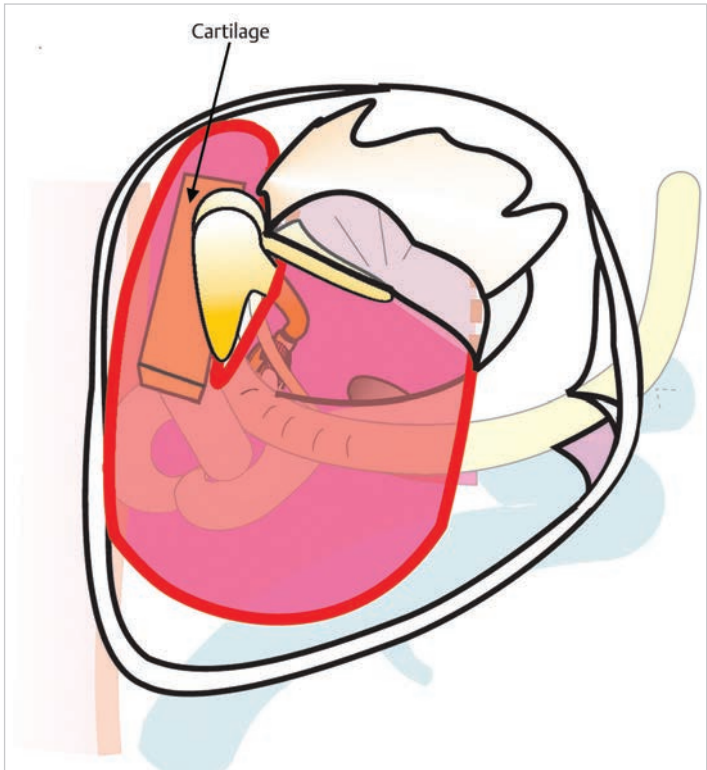


Fig. 7.215 A piece of cartilage is placed medial to the head of the malleus and the body of the incus and is covered with a tongue of fascia. The rest of the fascia is placed between the handle of the malleus and the long process of the incus.

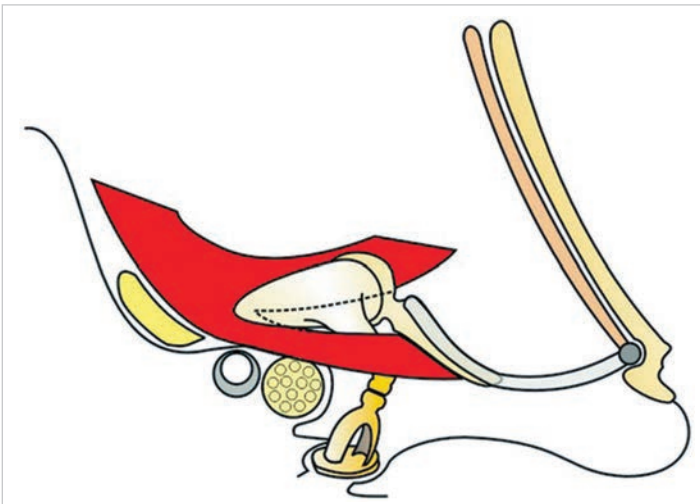


Fig. 7.216 Position of the fascia in modified Bondy technique.

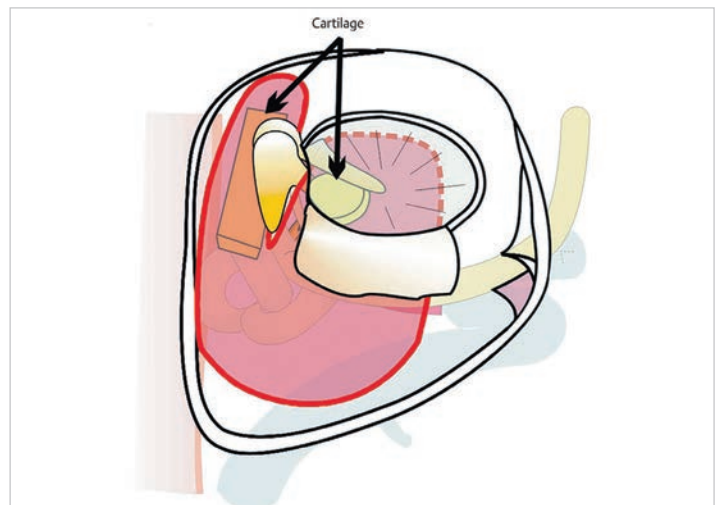


Fig. 7.217 An additional piece of cartilage is placed between the handle of the malleus and the long process of the incus, and the posterior meatal skin flap is reflected backward to cover the fascia.

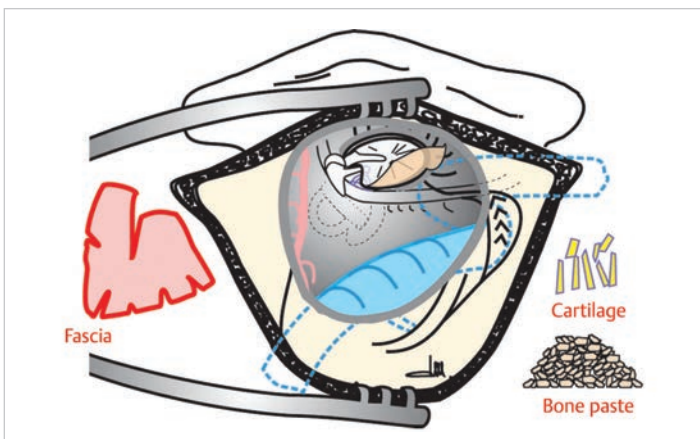


Fig. 7.218 Before reconstruction of the tympanic membrane.

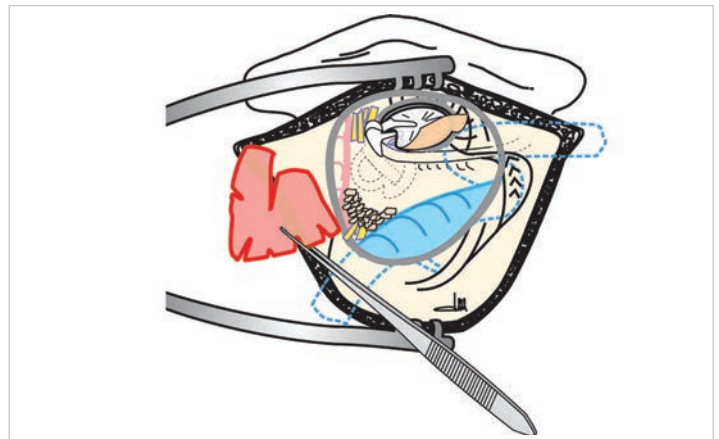


Fig. 7.219 Cartilage and bone paste in place.

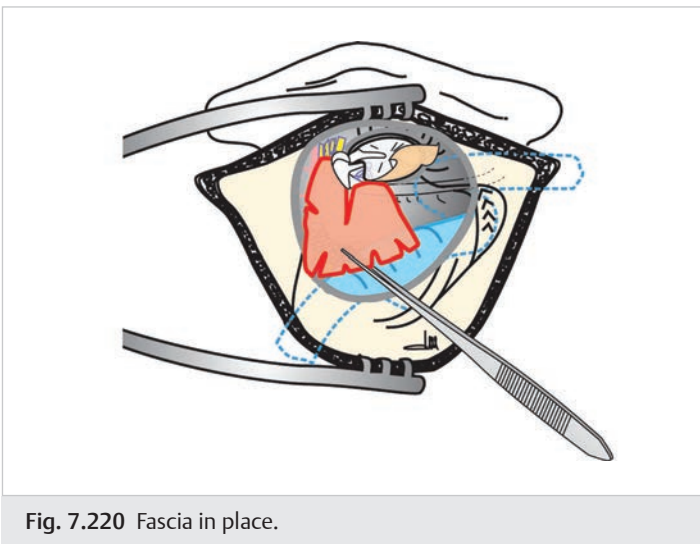


Fig. 7.220 Fascia in place.

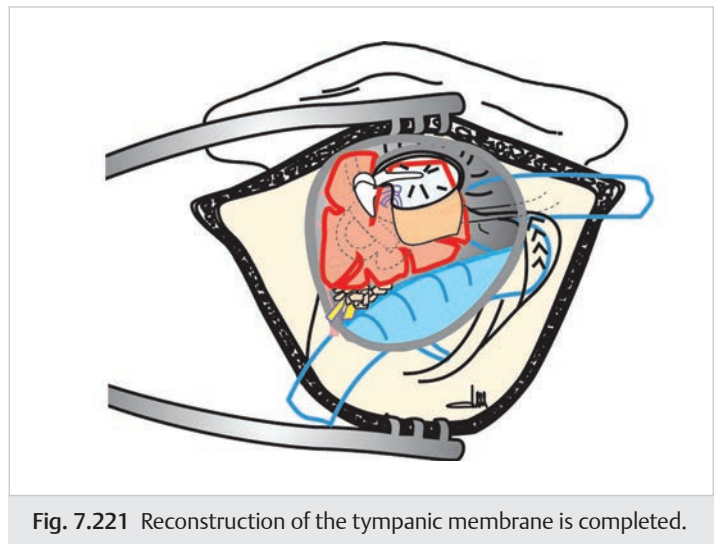


Fig. 7.221 Reconstruction of the tympanic membrane is completed.

Case 7.15 (Right Ear)

See ▶ Fig. 7.222, ▶ Fig. 7.223, ▶ Fig. 7.224, ▶ Fig. 7.225, ▶ Fig. 7.226, ▶ Fig. 7.227, ▶ Fig. 7.228, ▶ Fig. 7.229, ▶ Fig. 7.230, ▶ Fig. 7.231,

▶ Fig. 7.232, ▶ Fig. 7.233, ▶ Fig. 7.234, ▶ Fig. 7.235▶ Fig. 7.236, ▶ Fig. 7.237, ▶ Fig. 7.238, ▶ Fig. 7.239, ▶ Fig. 7.240, ▶ Fig. 7.241, ▶ Fig. 7.242, ▶ Fig. 7.243, ▶ Fig. 7.244, ▶ Fig. 7.245, ▶ Fig. 7.246, ▶ Fig. 7.247, ▶ Fig. 7.248, ▶ Fig. 7.249, ▶ Fig. 7.250.

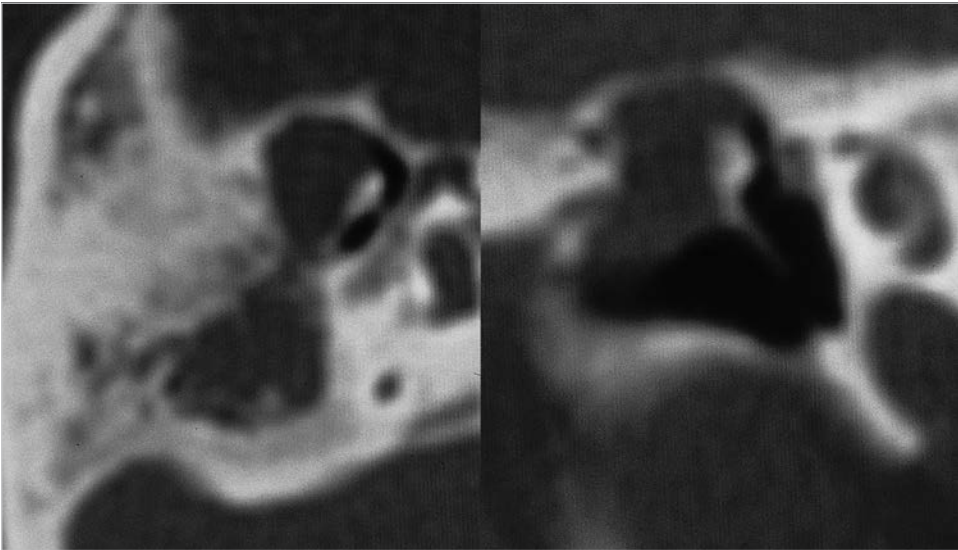


Fig. 7.222 Modified Bondy technique in lateral epitympanic cholesteatoma with normal hearing. This case is a perfect indication for the modified Bondy technique because of the localization of cholesteatoma lateral to the ossicular chain and sclerotic mastoid.

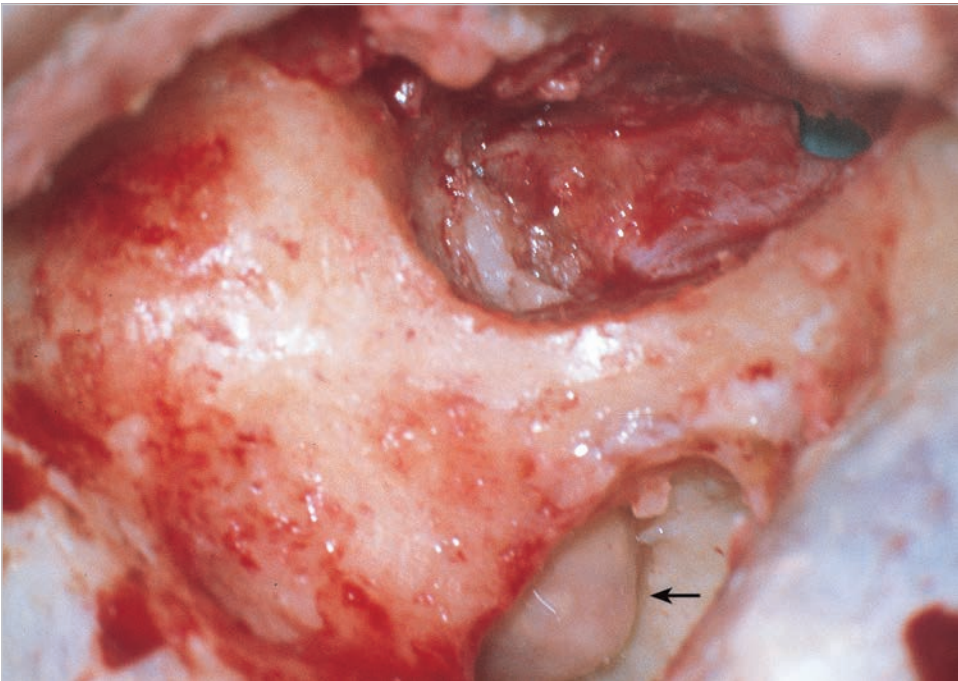


Fig. 7.223 Mastoidectomy is carried out and the antrum is opened. Since modified Bondy technique is indicated from the beginning, the posterior meatal wall is partially removed at this moment. Cholesteatoma (arrow) reaching the antrum and an entry of the cholesteatoma eroding the attic are seen.

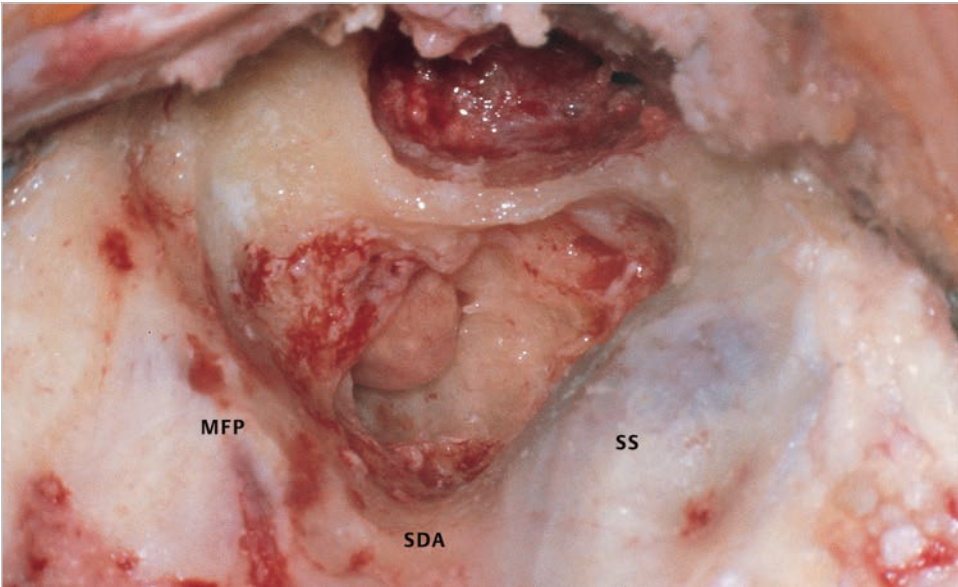


Fig. 7.224 The antrum is further opened. Note that the middle fossa plate and the sigmoid sinus plate are thinned and edges of the cavity are rounded to obtain a saucerized cavity. MFP, middle fossa plate; SDA, sinodural angle; SS, sigmoid sinus.

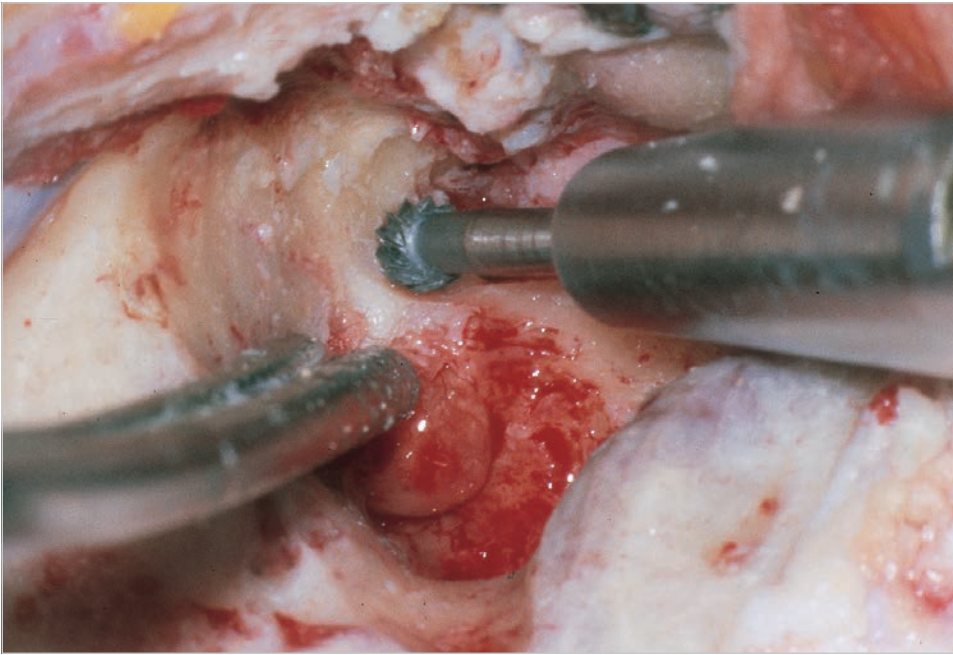


Fig. 7.225 The facial bridge is thinned with a cutting burr taking care not to touch the lateral process of the malleus.

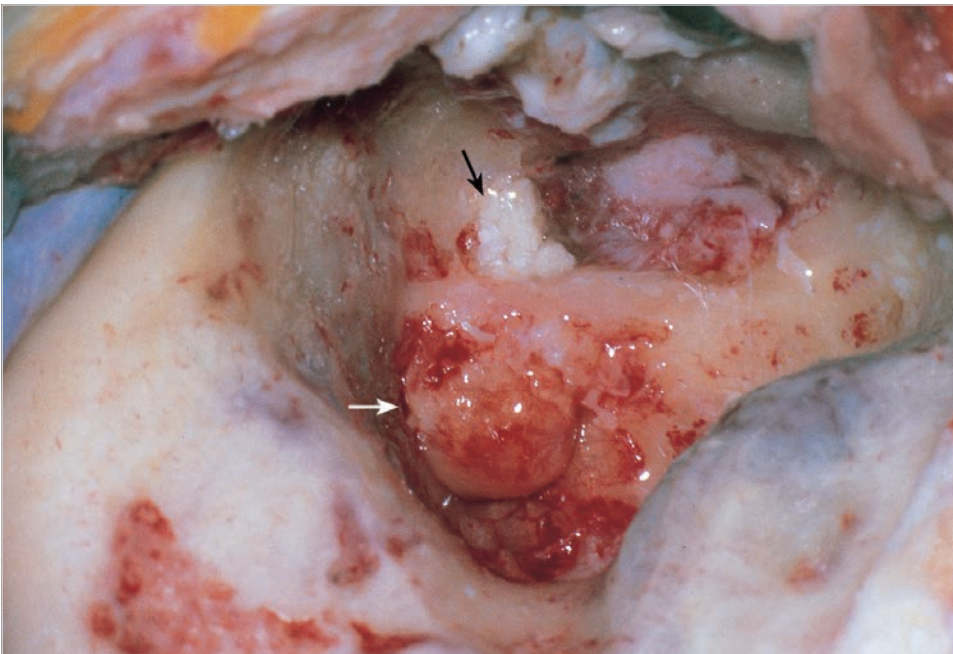


Fig. 7.226 Thinning of the facial bridge exposes lateral aspect of the cholesteatoma (arrows).

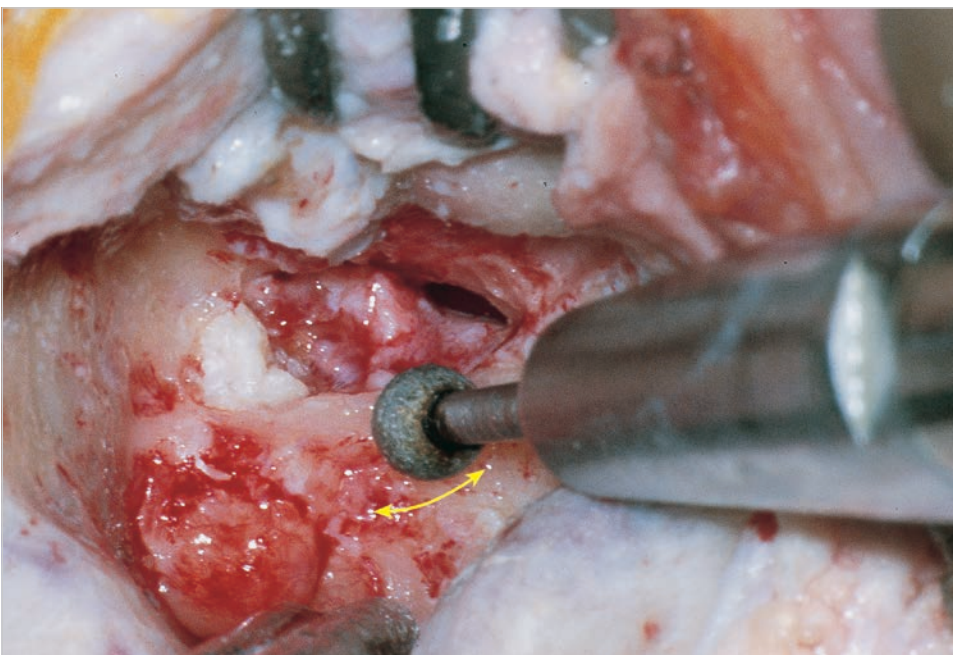


Fig. 7.227 The facial ridge is lowered with the largest possible diamond burr, with movement parallel to the nerve.

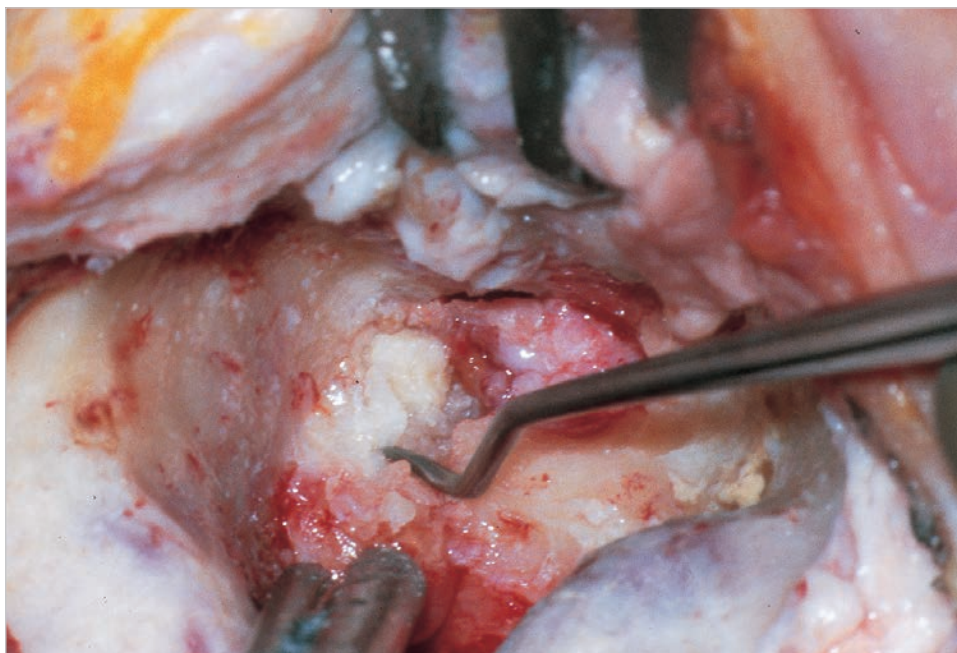


Fig. 7.228 The facial bridge is removed, and debulking of the cholesteatoma is performed with a tympanic sinus hook, taking care not to add excessive force to surrounding structures.

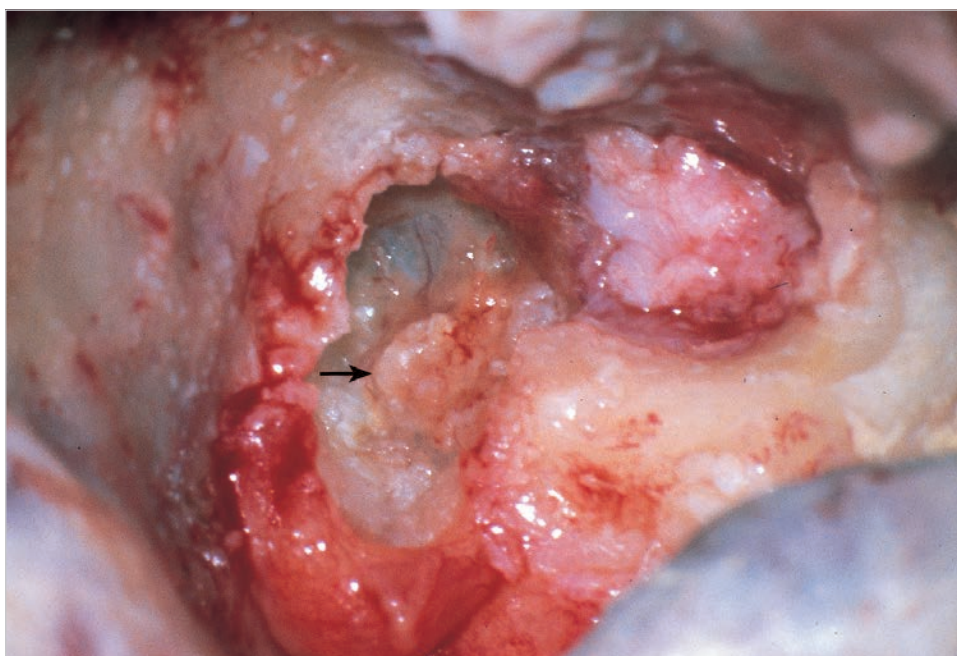


Fig. 7.229 Most of debris is removed from inside of the cholesteatoma. The remnant of the body of the incus is seen (arrow).

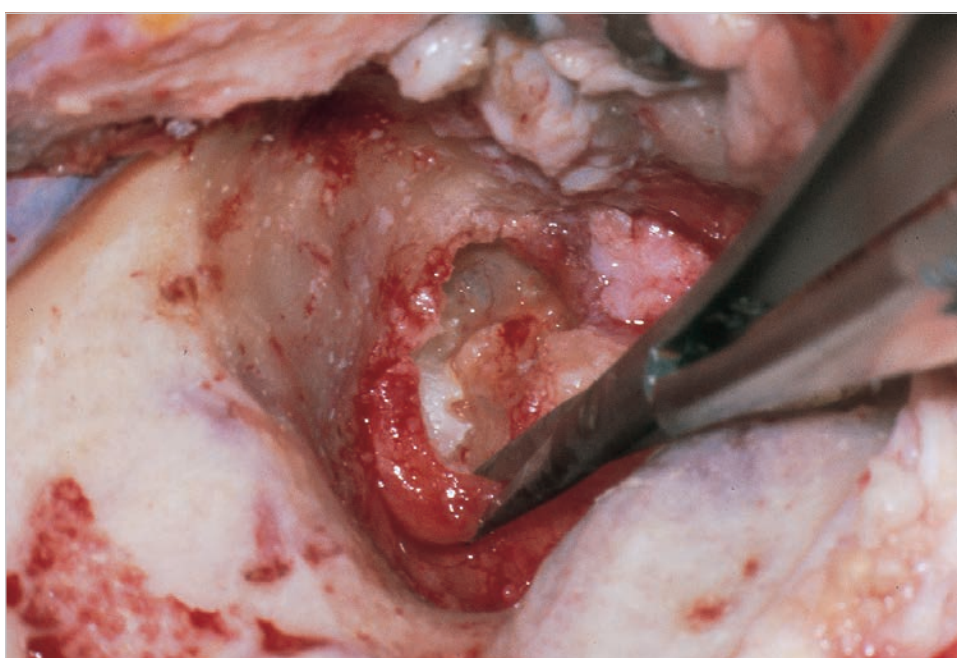


Fig. 7.230 The sac of the cholesteatoma is cut with scissors to facilitate dissection from the medial wall and evacuation of debris.

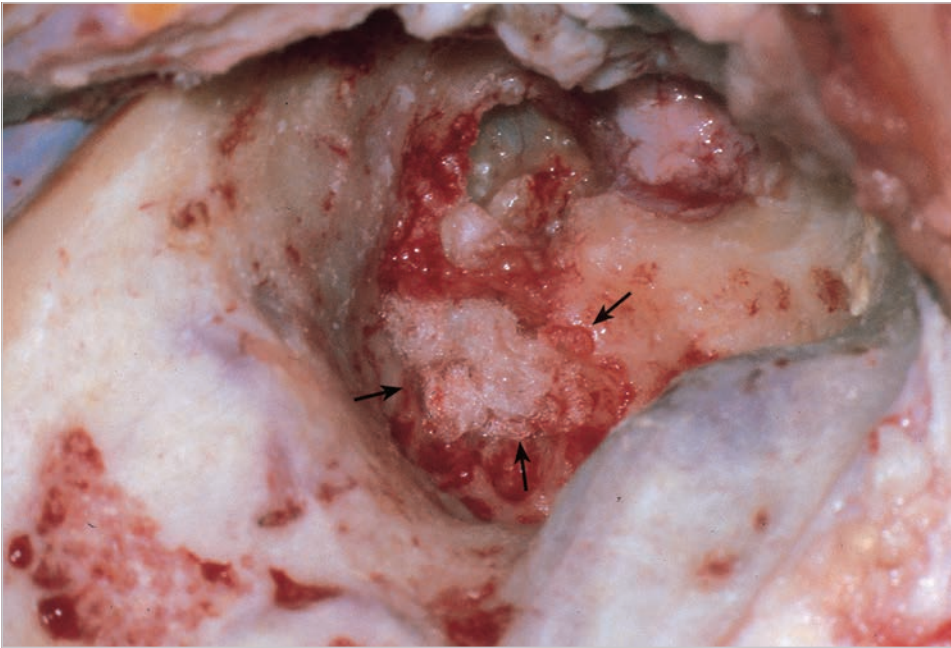


Fig. 7.231 The sac is opened (*arrows*).

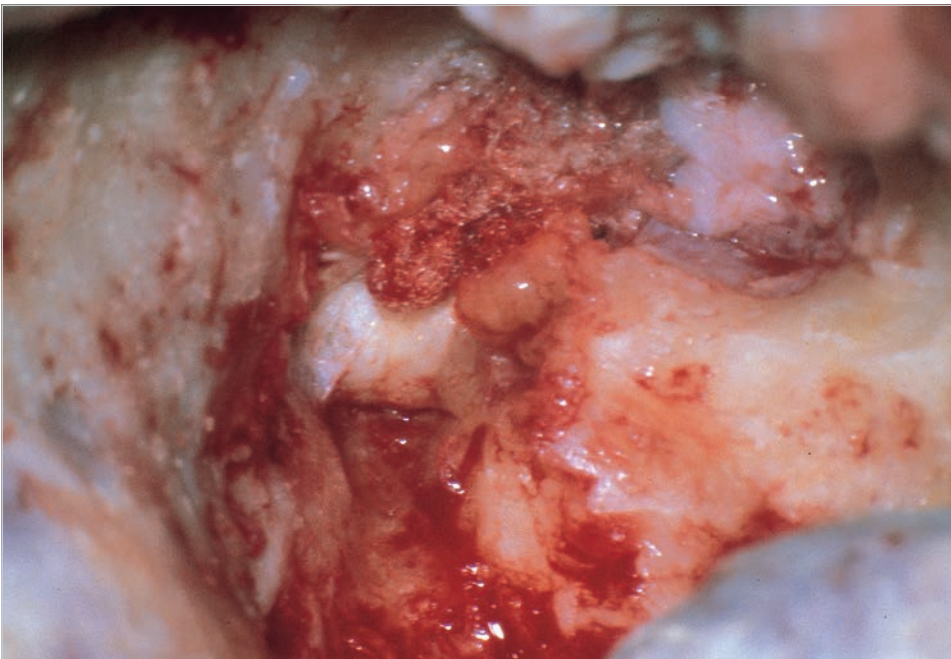


Fig. 7.232 Blunt dissection of cholesteatoma matrix from the medial wall is carried out with a piece of cottonoid.

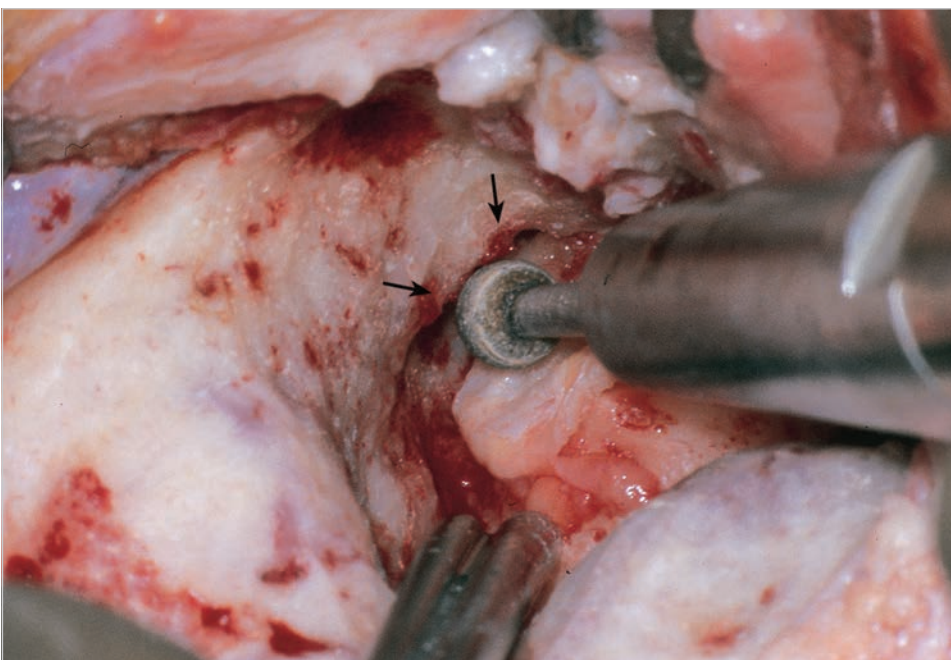


Fig. 7.233 The bony overhang in the attic from the middle fossa plate (*arrows*) is carried out with the largest possible diamond burr. Care should be taken not to touch the ossicular chain, since articulations between the ossicles remain intact in modified Bondy technique.

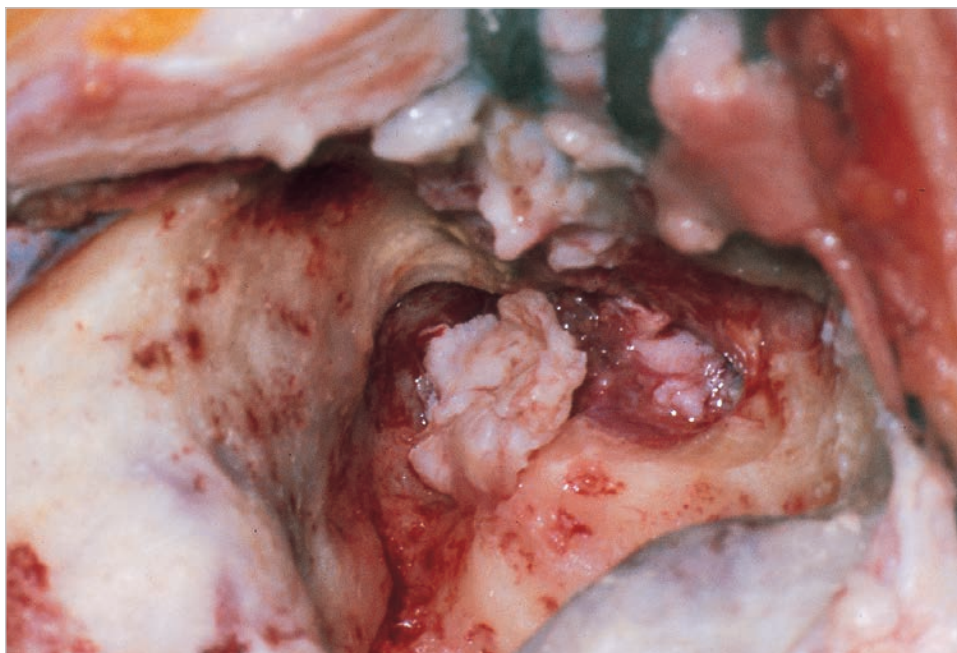


Fig. 7.234 The attic is fully opened anterosuperiorly. Cholesteatoma can be observed sufficiently.

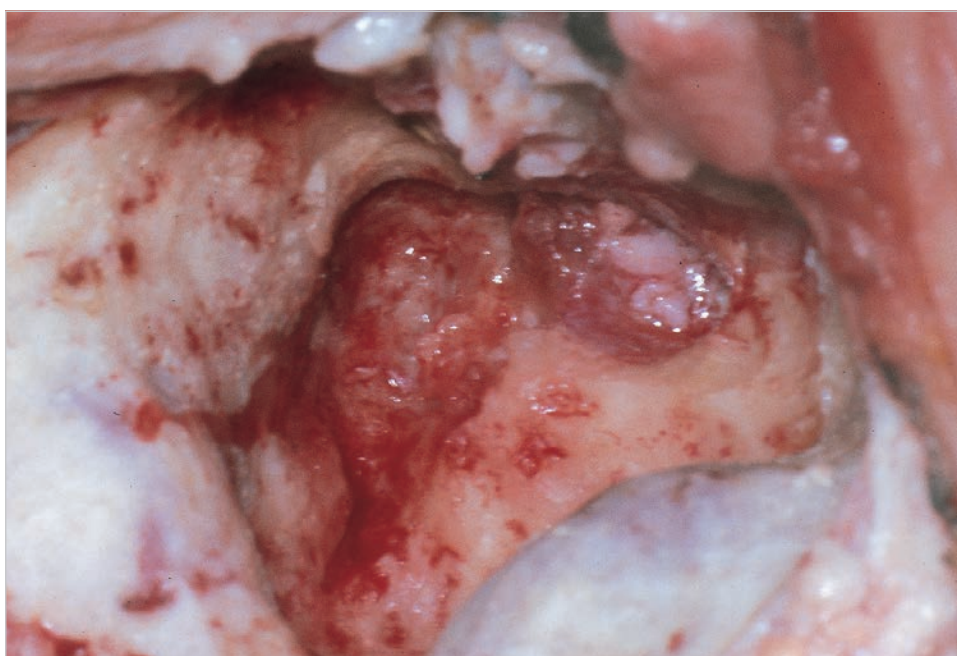


Fig. 7.235 The cholesteatoma is eradicated from the attic.

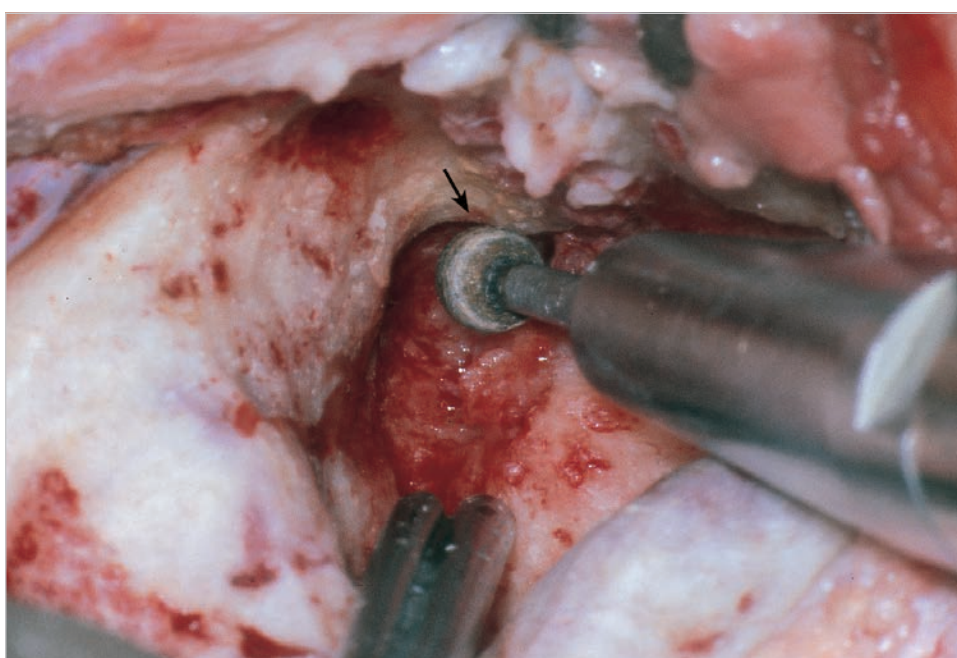


Fig. 7.236 A bony overhang anterior to the attic (arrow) is drilled with a diamond burr to enhance access to the anterior attic during follow-up.

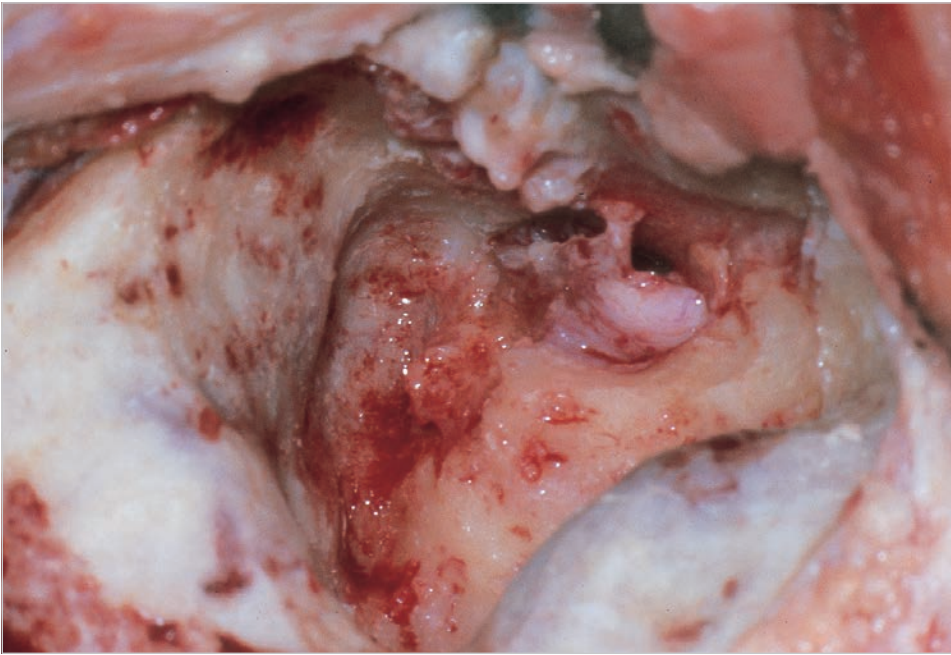


Fig. 7.237 The attic is completely opened and visualized.

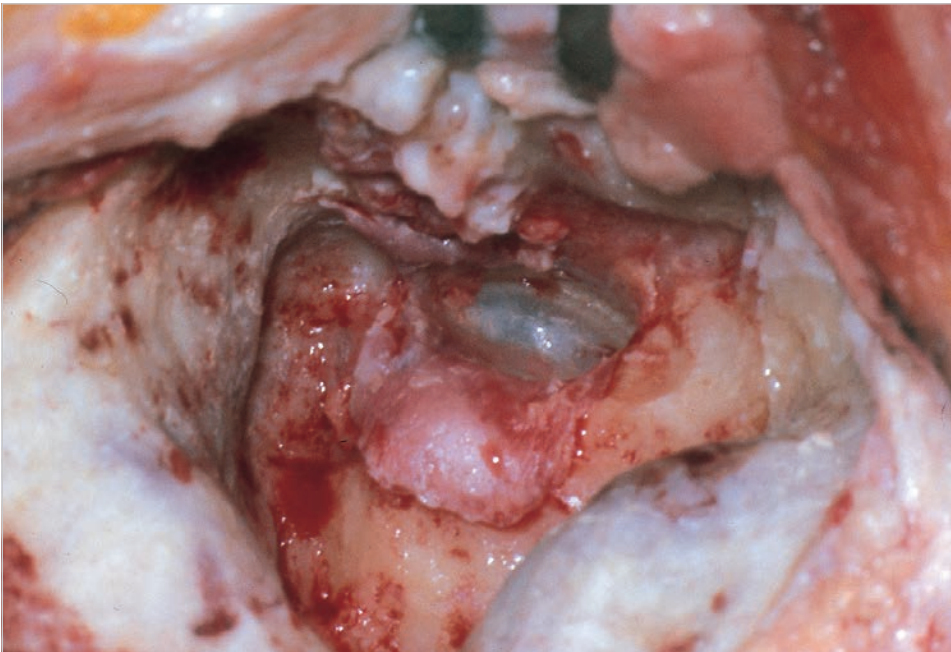


Fig. 7.238 The meatal flap is replaced on the facial ridge to estimate its height. In this case, the ridge is still too high.

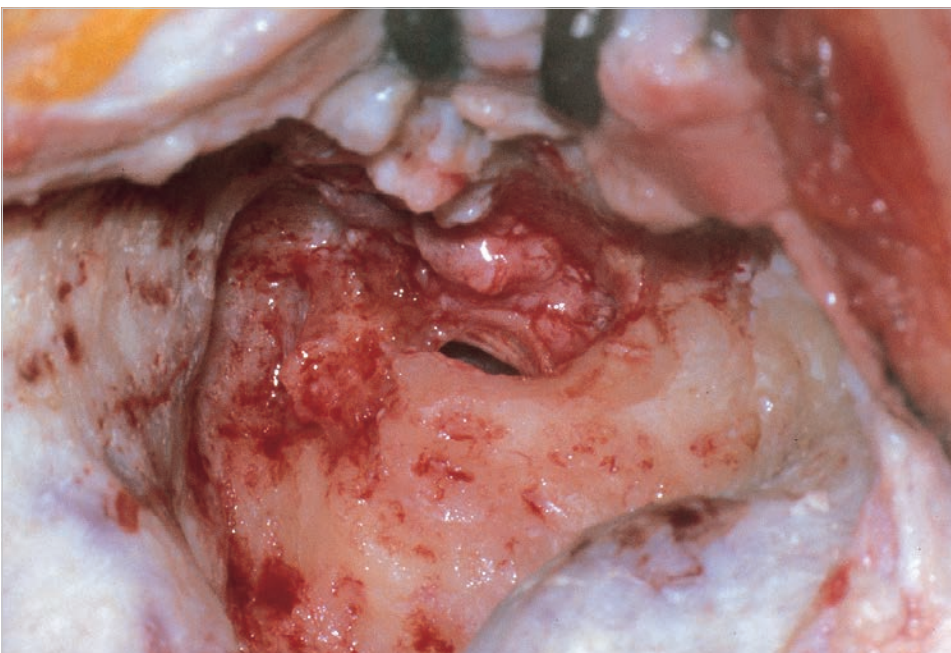


Fig. 7.239 The tympanic annulus is detached from the tympanic sulcus posteriorly, and the facial ridge and the posterior buttress are exposed. At the same time, absence of cholesteatoma in the mesotympanum is confirmed.

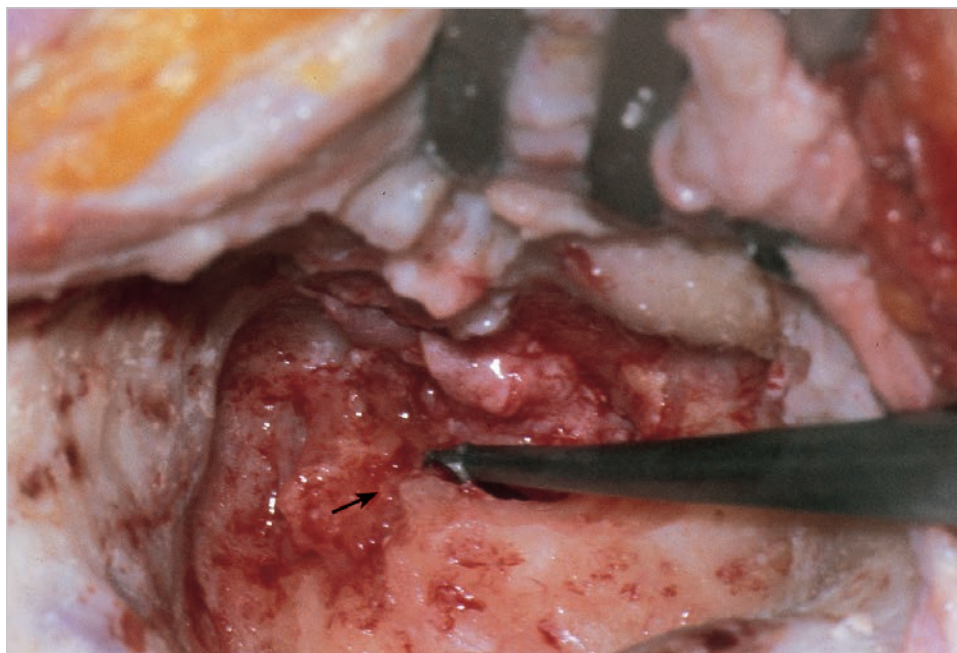


Fig. 7.240 The posterior buttress (*arrow*) is removed with a small curette.

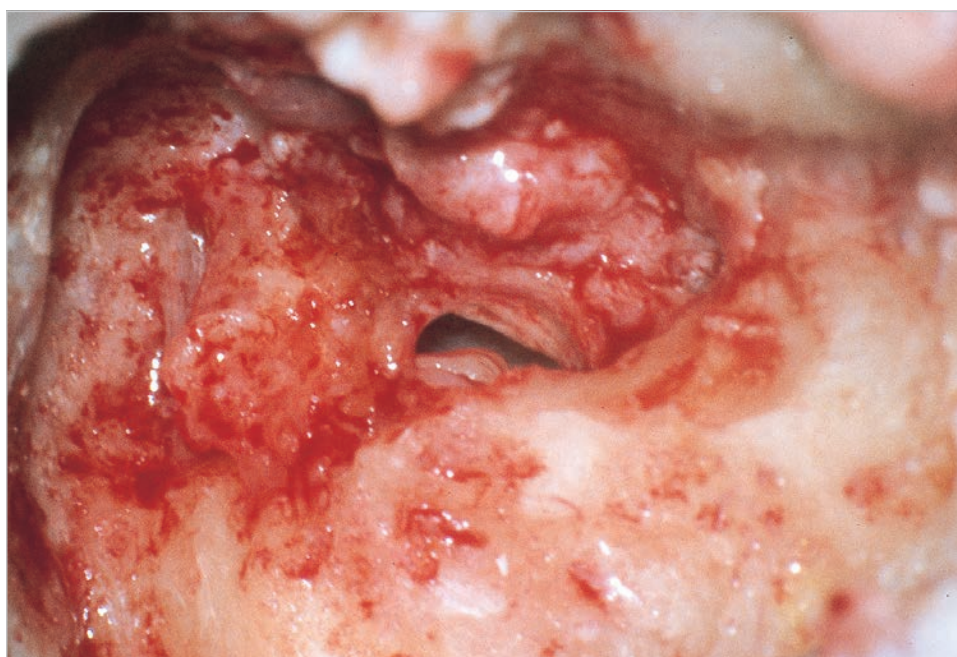


Fig. 7.241 Removal of the posterior buttress enhances visualization of the incudostapedial joint.

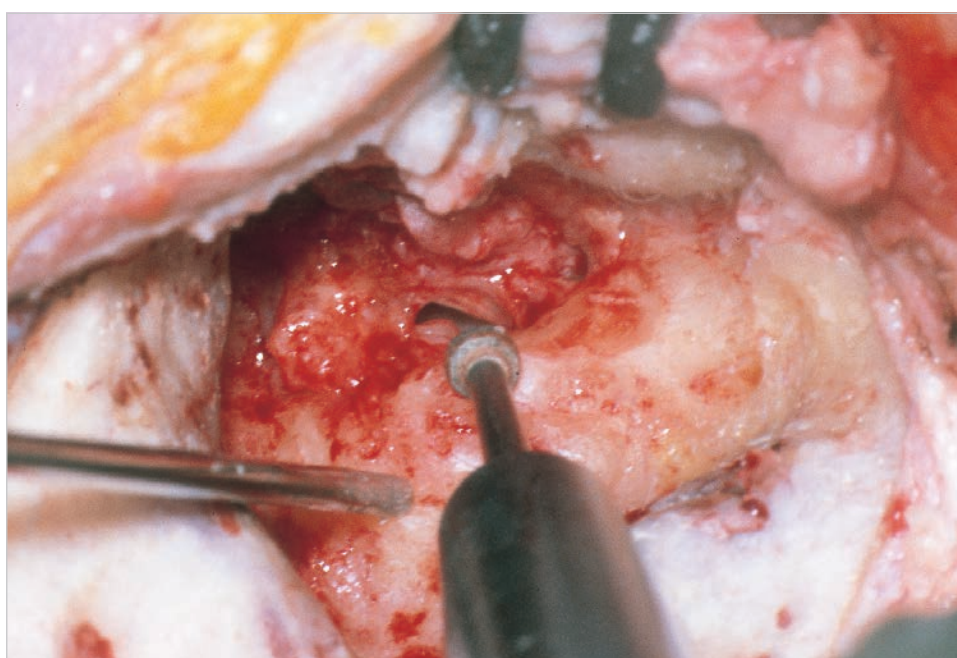


Fig. 7.242 The facial ridge is lowered with the largest possible diamond burr with movement parallel to the nerve.

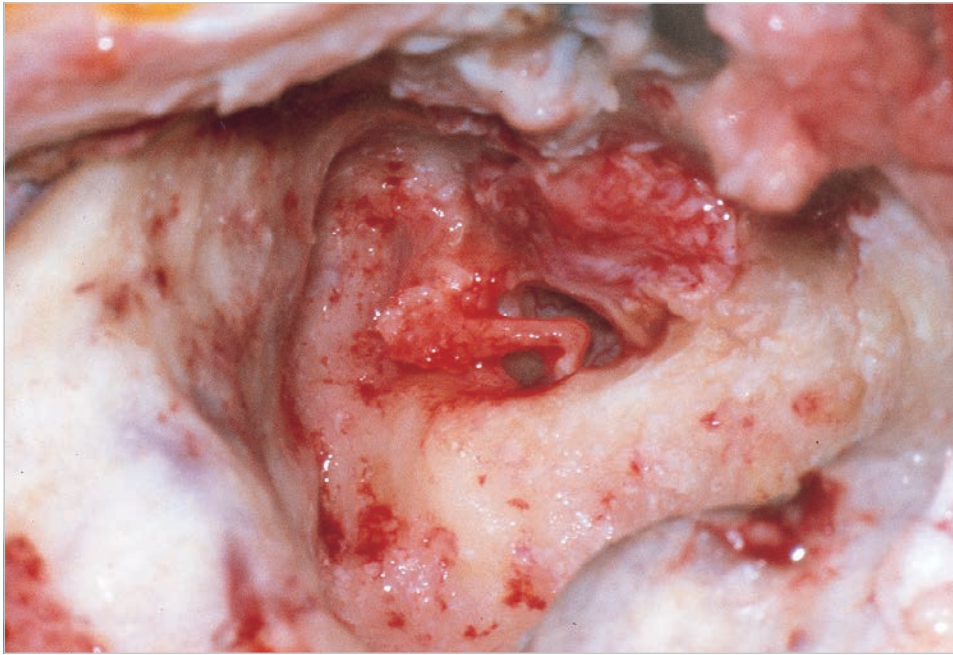


Fig. 7.243 The facial ridge is sufficiently lowered, and granulation tissue around the incus residue is removed carefully. The remaining ossicular chain is seen. The short process of the incus is eroded.



Fig. 7.244 A small cut that passes the eroded remnant of the chain is made in the temporalis fascia. Each segment is placed as follows. 1, between the medial wall of the attic and the remnant of the ossicular chain; 2, between the tympanic membrane and the long process of the incus; 3, on the medial wall of the antrum.

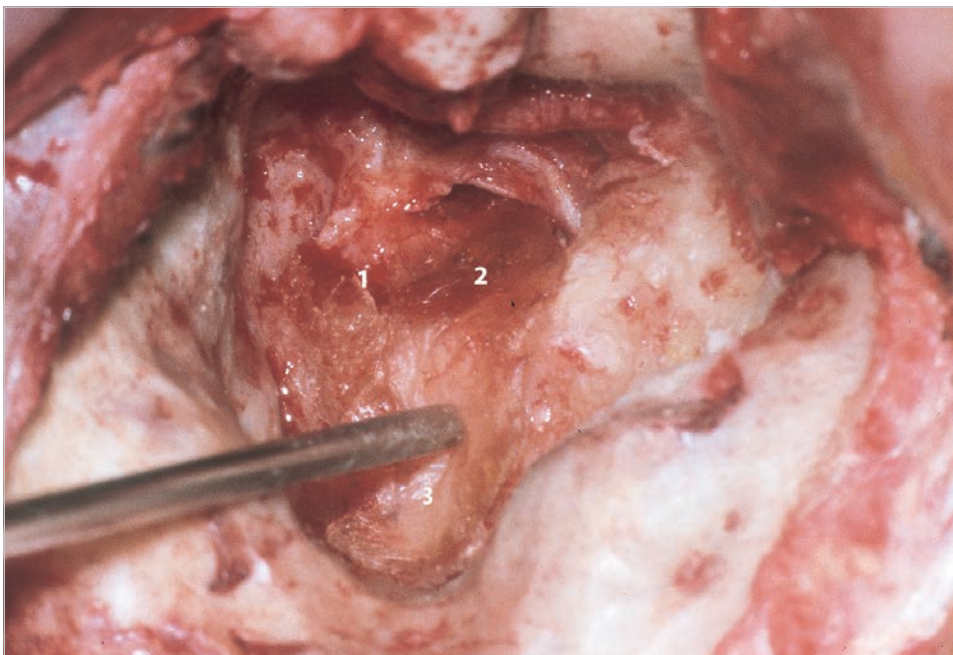


Fig. 7.245 The fascia is introduced into the cavity. The larger tongue (2) of the fascia is inserted into the tympanic cavity, posteriorly to the malleus. The smaller tongue (1) goes anteriorly to it.

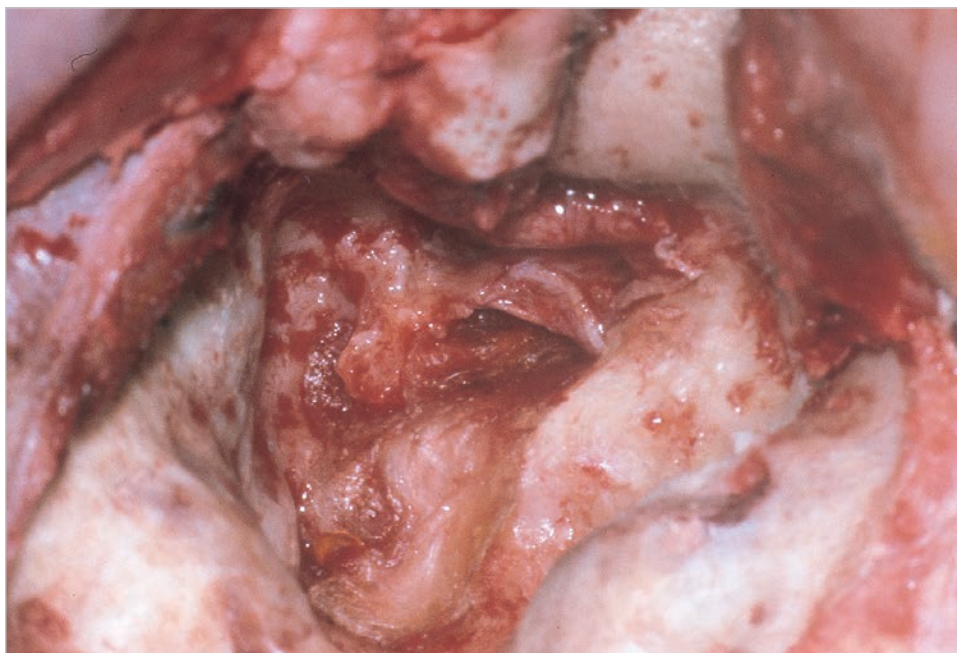


Fig. 7.246 Placement of the fascia is completed.

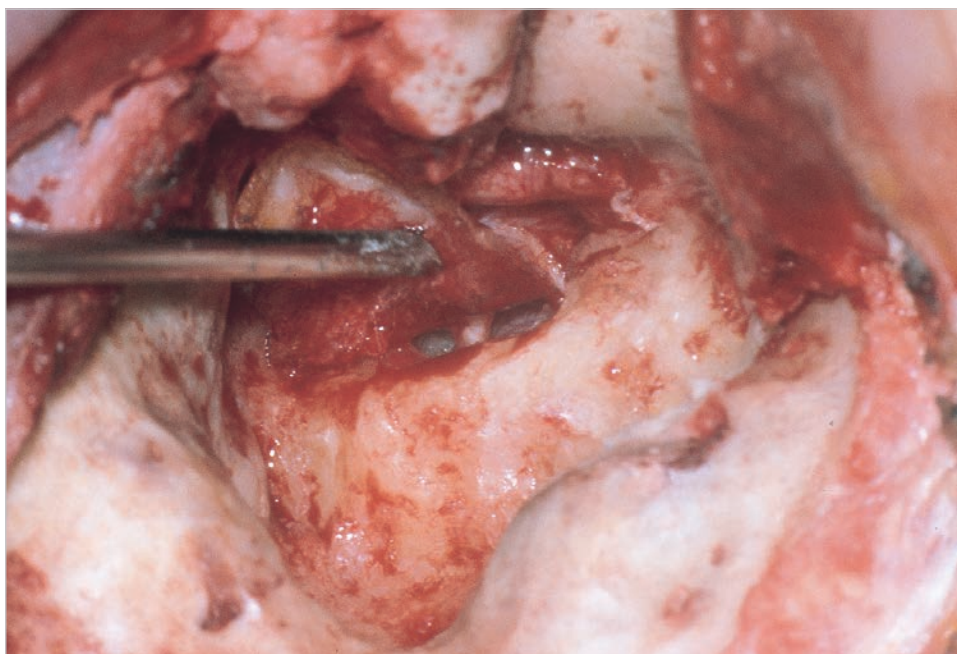


Fig. 7.247 The fascia is folded anteriorly to open the tympanic cavity.

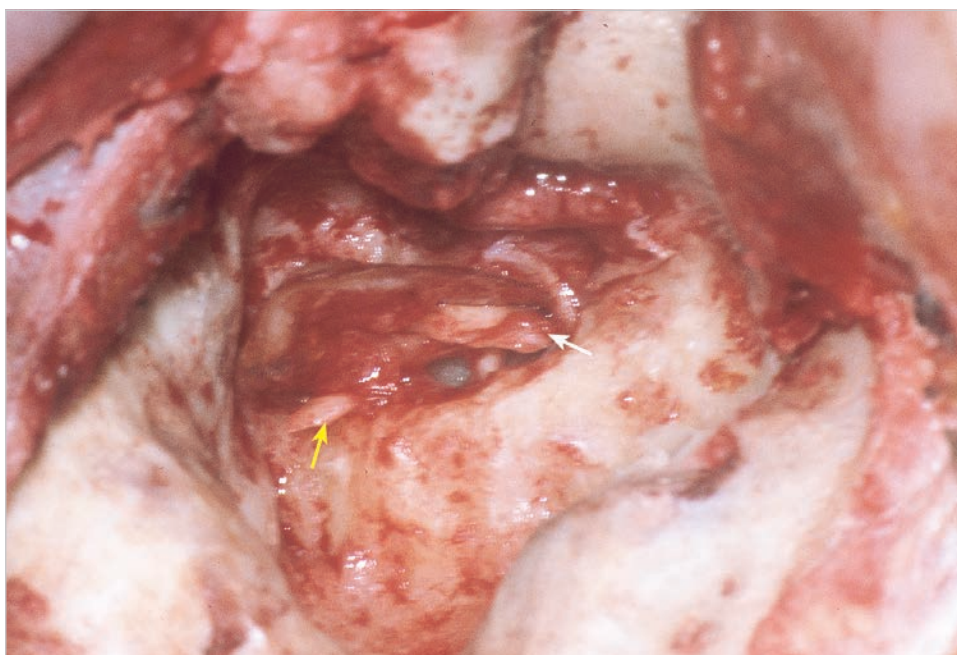


Fig. 7.248 Two pieces of conchal cartilage are used to prevent retraction of the tympanic membrane that may cause recurrence of cholesteatoma and/or erosion of the chain. Larger cartilage (*white arrow*) is placed lateral to the long process of the incus, and smaller cartilage (*yellow arrow*) is placed on the medial wall of the attic, medial to the head of the malleus and the body of the incus.

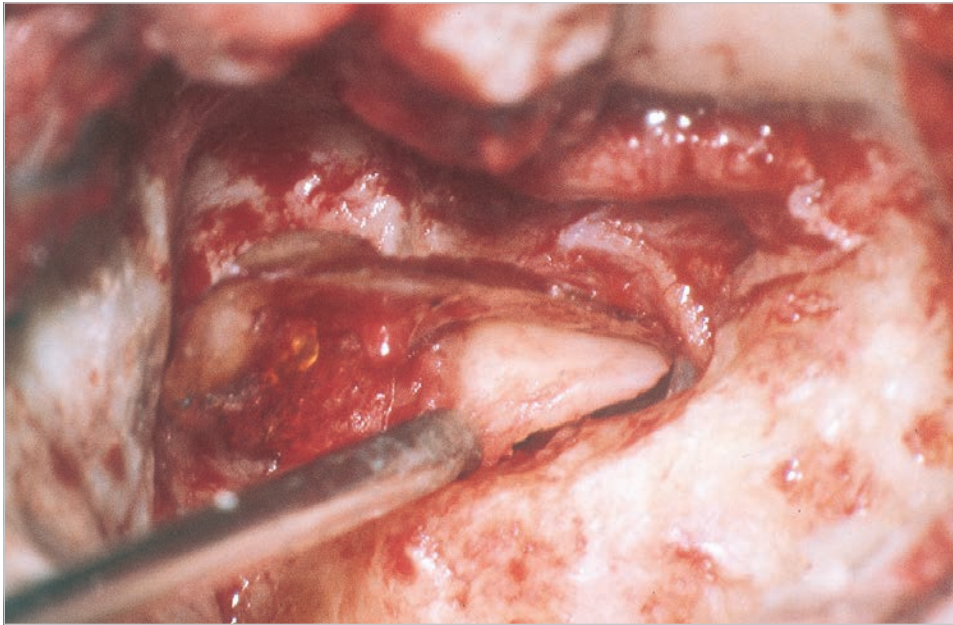


Fig. 7.249 The cartilage lateral to the long process of the incus is seen.

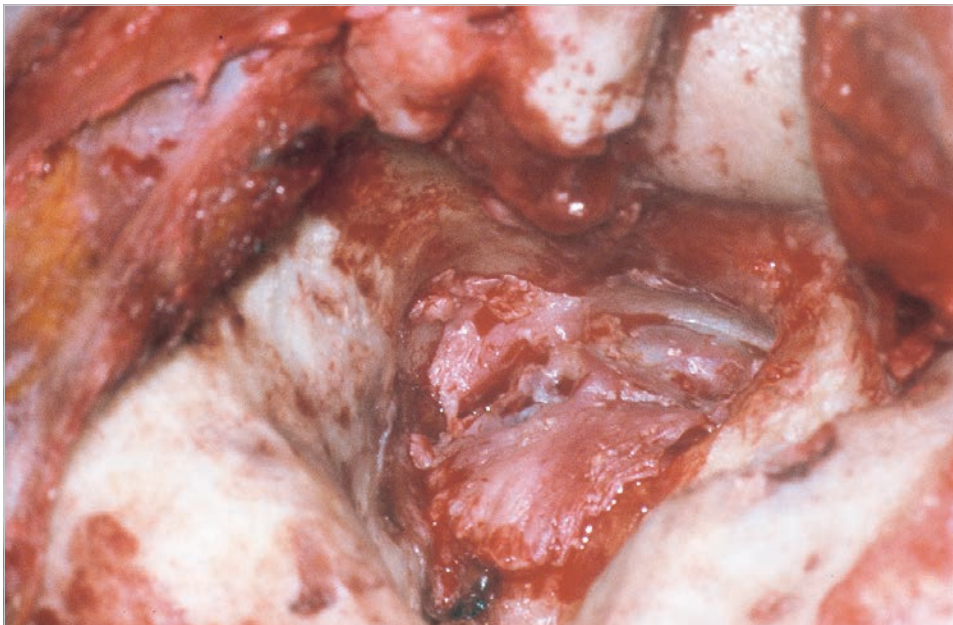


Fig. 7.250 The meatal flap is replaced on the fascia.

Case 7.16 (Left Ear)

See ► Fig. 7.251, ► Fig. 7.252, ► Fig. 7.253, ► Fig. 7.254, ► Fig. 7.255, ► Fig. 7.256, ► Fig. 7.257, ► Fig. 7.258, ► Fig. 7.259, ► Fig. 7.260, ► Fig. 7.261.

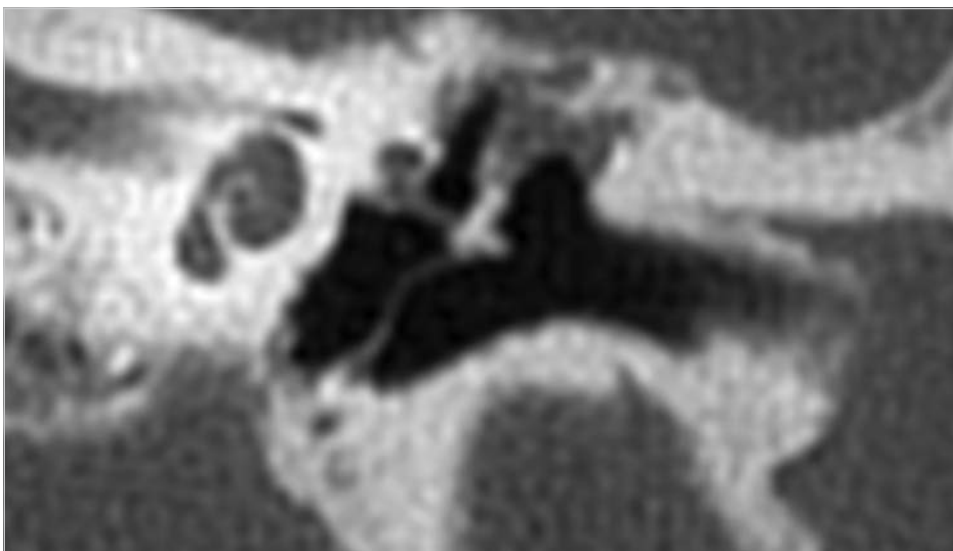


Fig. 7.251 A case of epitympanic cholesteatoma located laterally to the ossicular chain. The ossicular chain is heavily eroded in the attic, but preoperative hearing remains good with minimal air–bone gap.



Fig. 7.252 Mastoidectomy is carried out to reach the antrum.

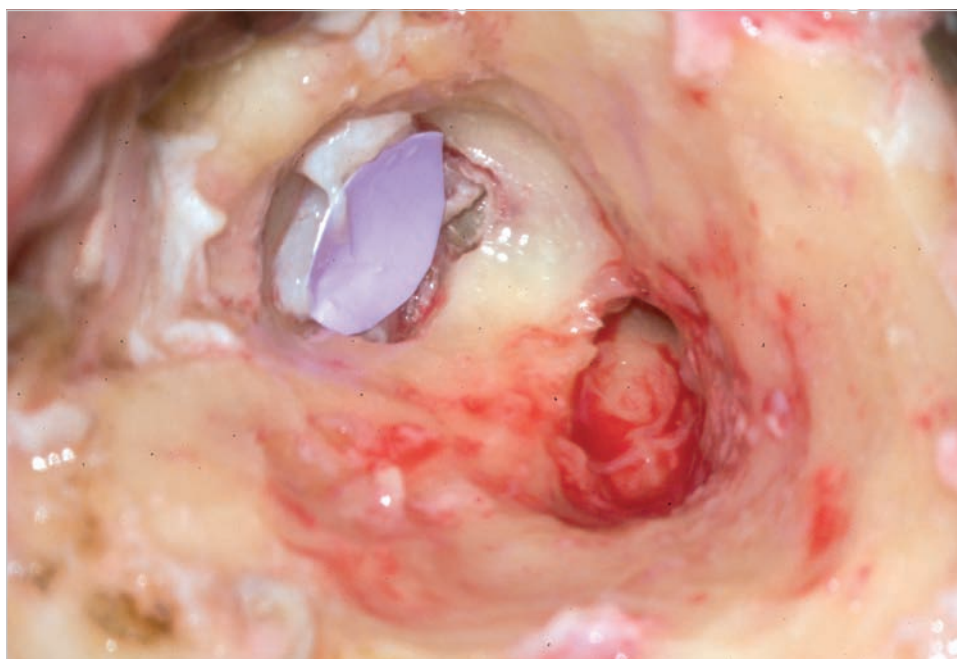


Fig. 7.253 The posterior canal wall is partially removed to reach the area near the tympanic membrane. The aluminum sheeting is used to protect the meatal skin.

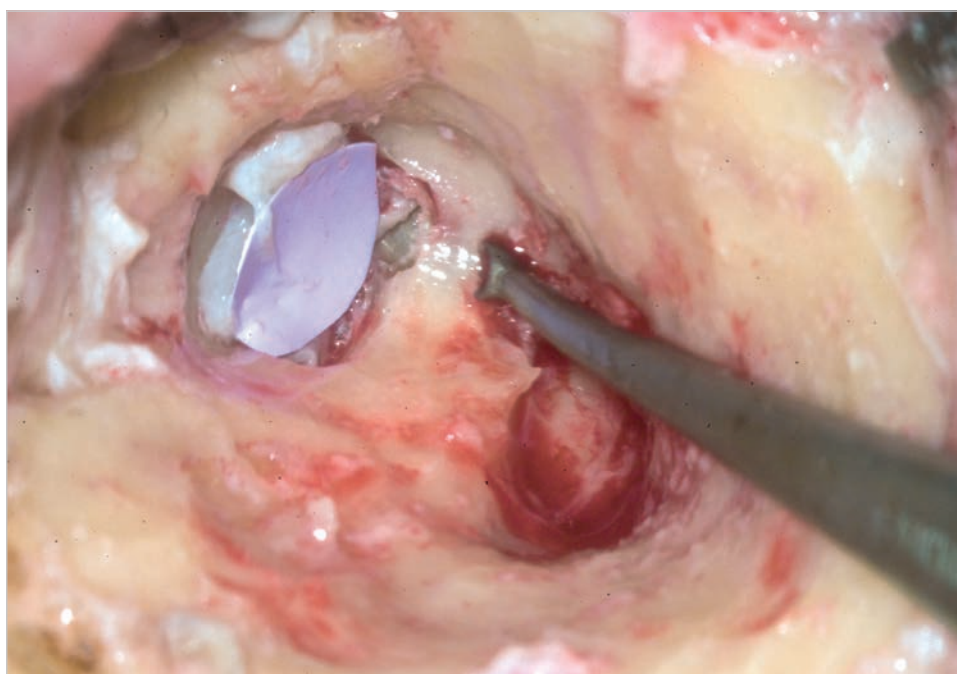


Fig. 7.254 After thinning the lateral wall of the attic with the burr, the curette is used to remove the remaining portion to avoid damaging the underlying intact ossicular chain.

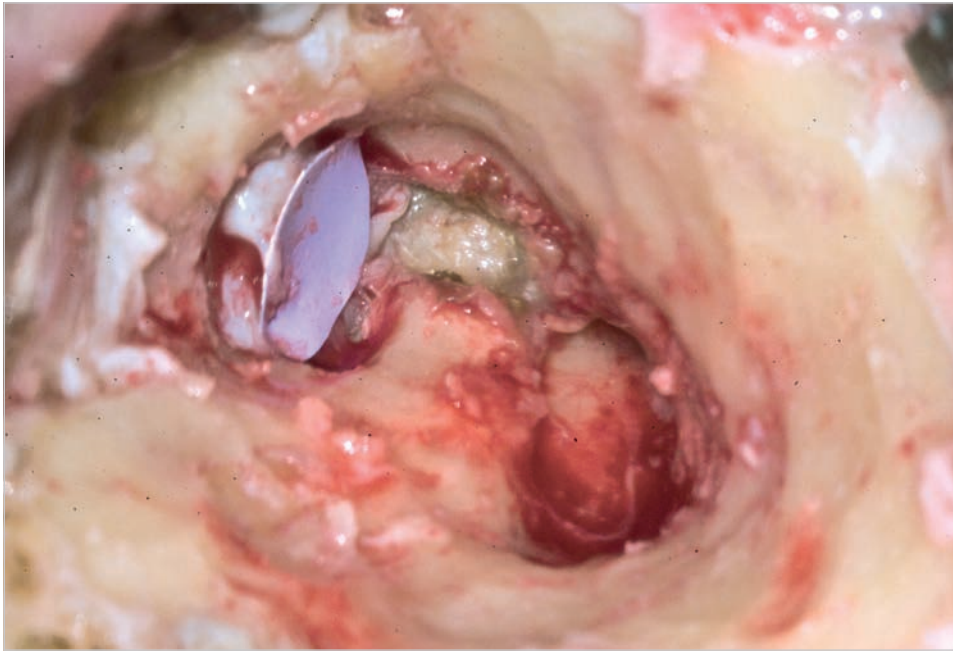


Fig. 7.255 The matrix of cholesteatoma occupying the attic is opened. The posterior end of cholesteatoma reaching the aditus is in view. The skin is covering the short process of the incus.

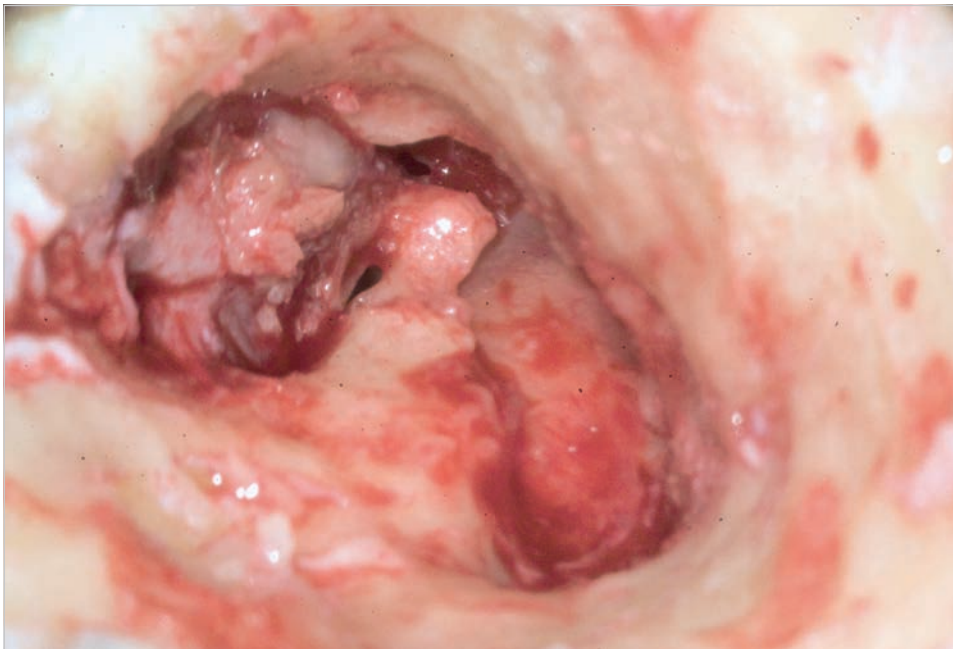


Fig. 7.256 The skin has been dissected from the ossicular chain, and the eroded incus is now visualized.

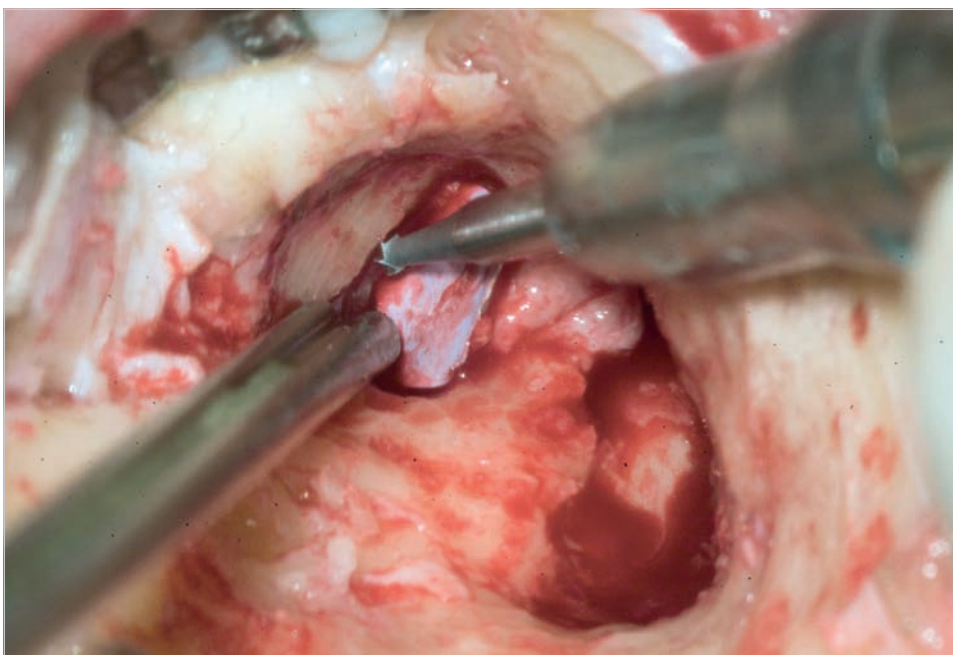


Fig. 7.257 The anterior meatal skin is detached medially and protected by the aluminum sheeting. The anterior bony wall is drilled to obtain better access to the tympanic membrane.

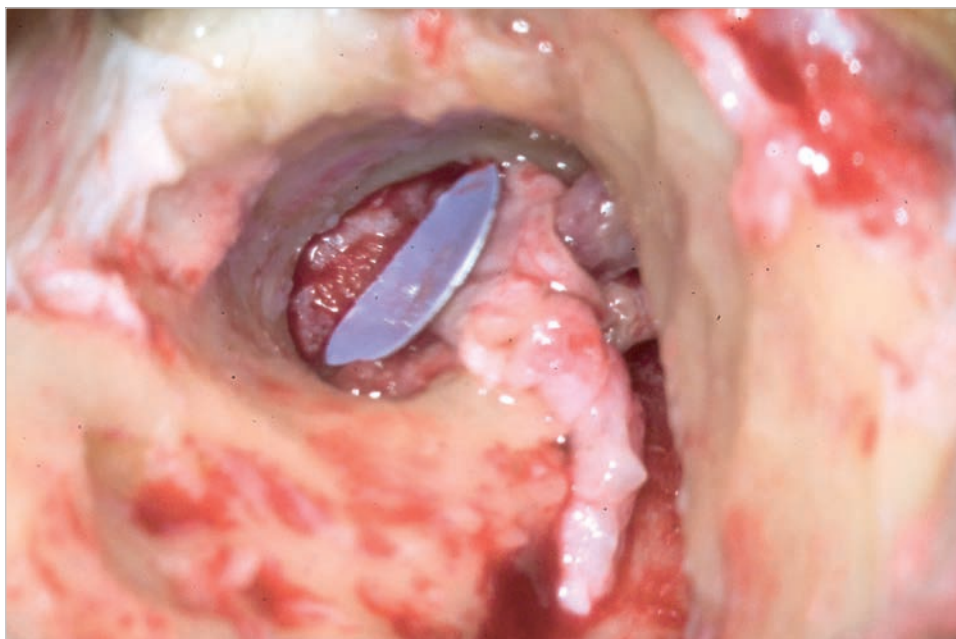


Fig. 7.258 The drilling of the anterior wall is completed.

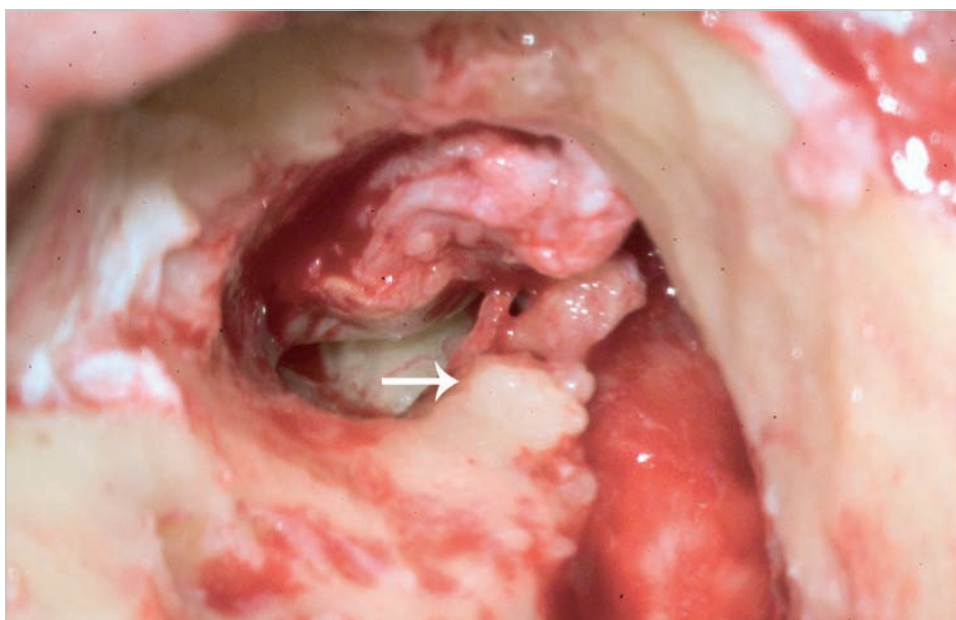


Fig. 7.259 Absence of cholesteatoma in the tympanic cavity is verified by opening the tympanic cavity by detaching posterior half the fibrous annulus. The chorda tympani nerve free of disease is left in place (arrow).



Fig. 7.260 The tympanic cavity is packed with Gelfoam for reconstruction.

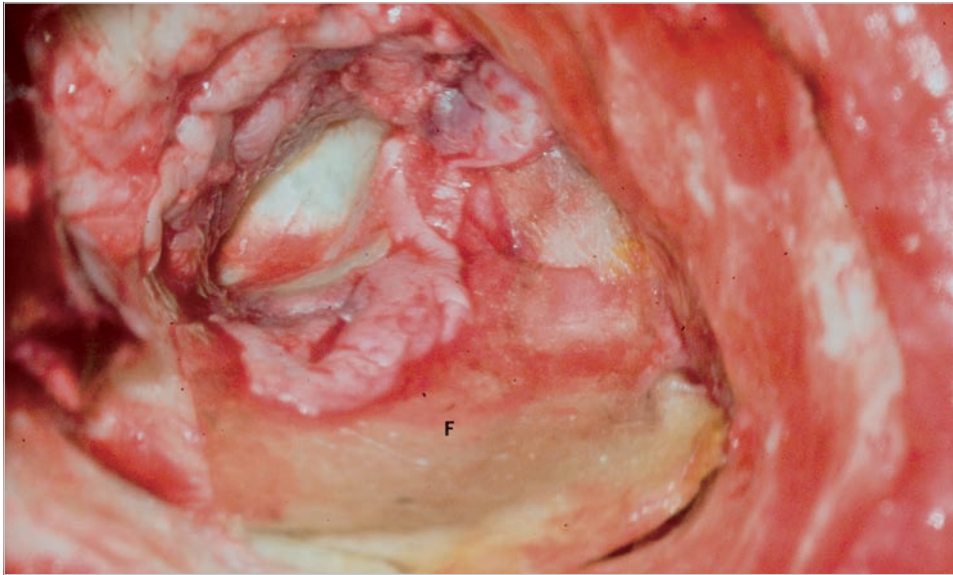


Fig. 7.261 A piece of tragal cartilage is placed under the ossicular chain to prevent invagination of skin into the tympanic cavity postoperatively. The temporalis fascia is grafted underlay, and the tympanomeatal flap is replaced over the fascia (F).

Case 7.17 (Left Ear)

See ► Fig. 7.262, ► Fig. 7.263, ► Fig. 7.264, ► Fig. 7.265, ► Fig. 7.266, ► Fig. 7.267, ► Fig. 7.268, ► Fig. 7.269, ► Fig. 7.270, ► Fig. 7.271, ► Fig. 7.272, ► Fig. 7.273, ► Fig. 7.274.

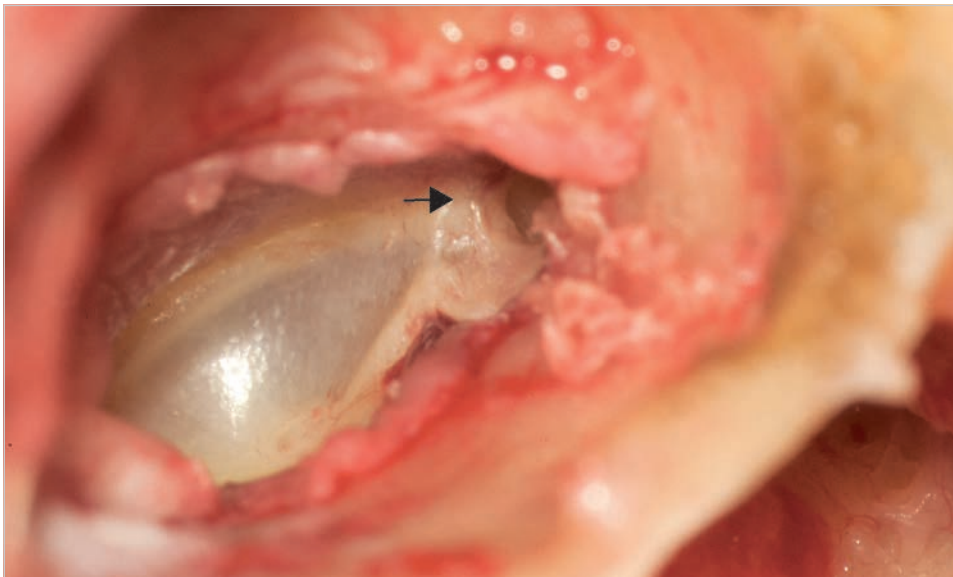


Fig. 7.262 A canal wall up mastoidectomy is completed. A small dry entrance of cholesteatoma is seen in the pars flaccida (arrow).

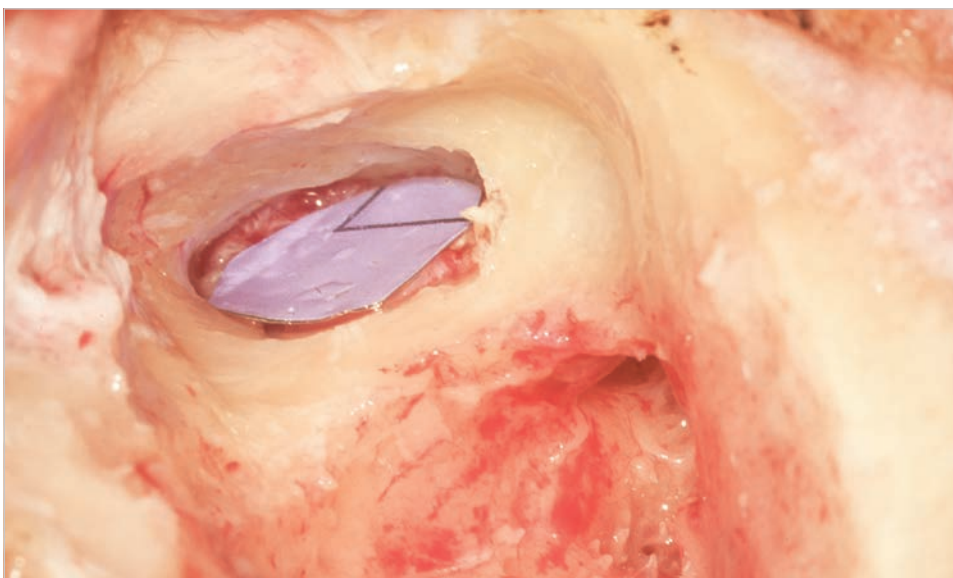


Fig. 7.263 Removal of the posterior wall is started. The tympanomeatal flap is protected with an aluminum sheeting.

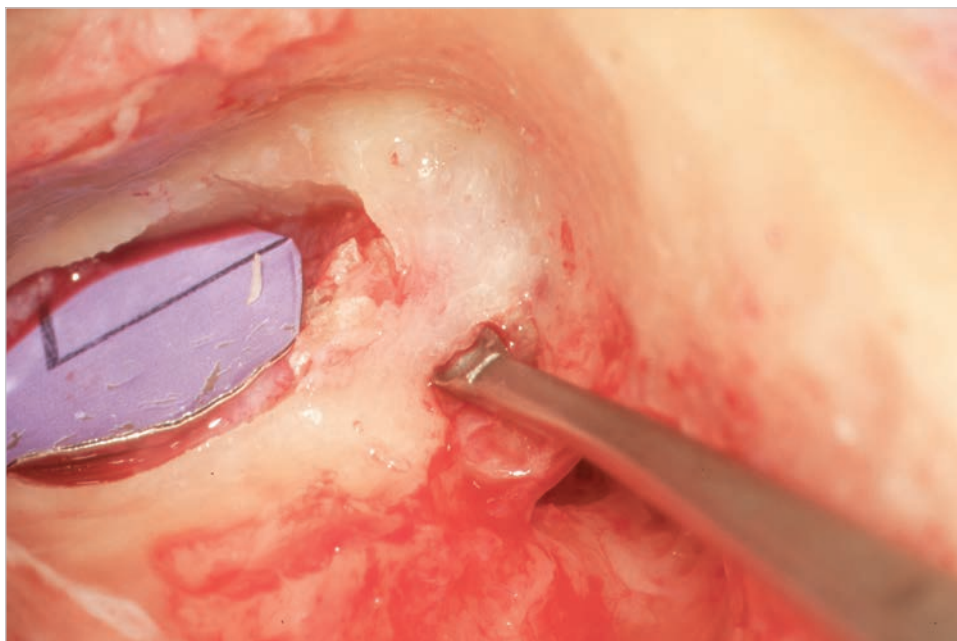


Fig. 7.264 The superior meatal wall lateral to the cholesteatoma is thinned, and the final bone is removed with a curette.

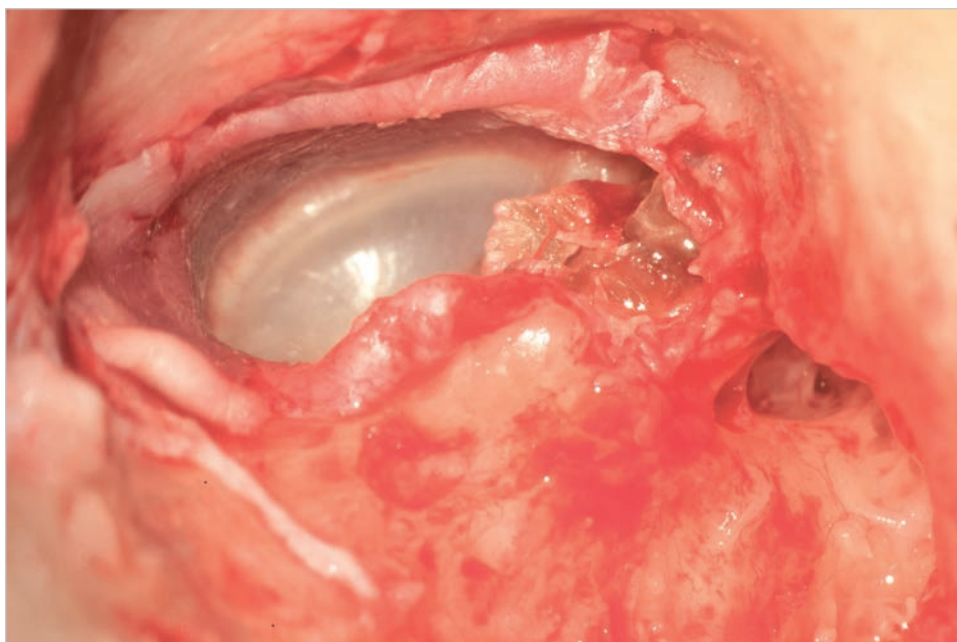


Fig. 7.265 A hard crust is accumulated in the posterior part of the cholesteatoma.

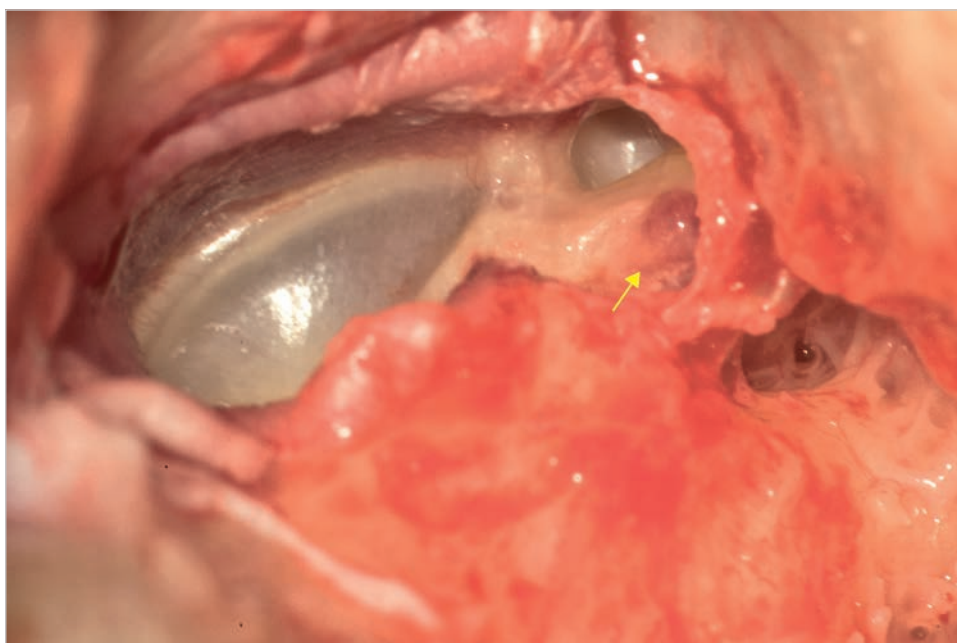


Fig. 7.266 Removal of the crust revealed granulation tissue formed over the body of incus (arrow).

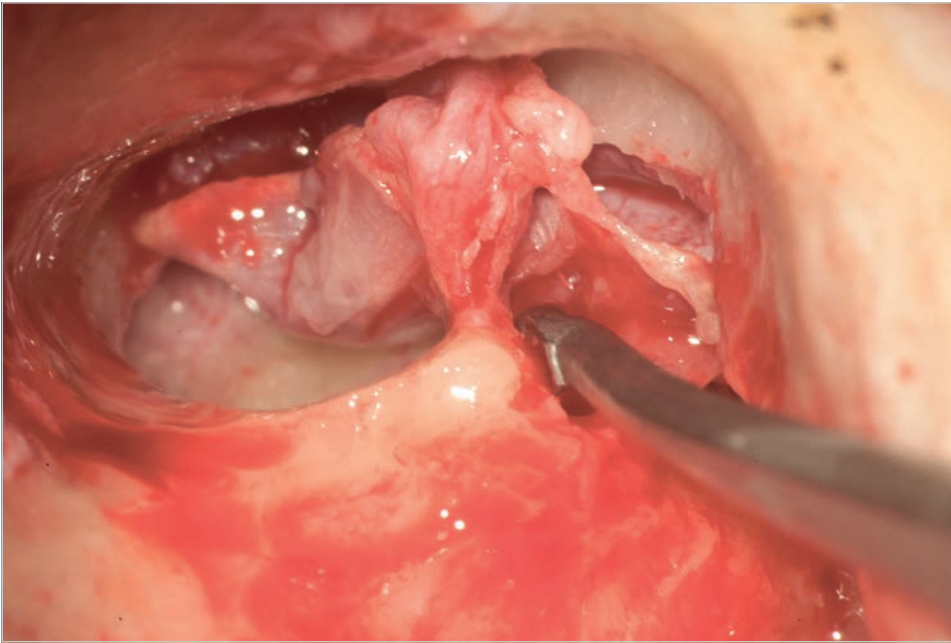


Fig. 7.267 The tympanic cavity is opened from inferior, and absence of cholesteatoma is verified. The posterior buttress is removed with a curette. The procedure also ensures removal of the skin adherent to this area.

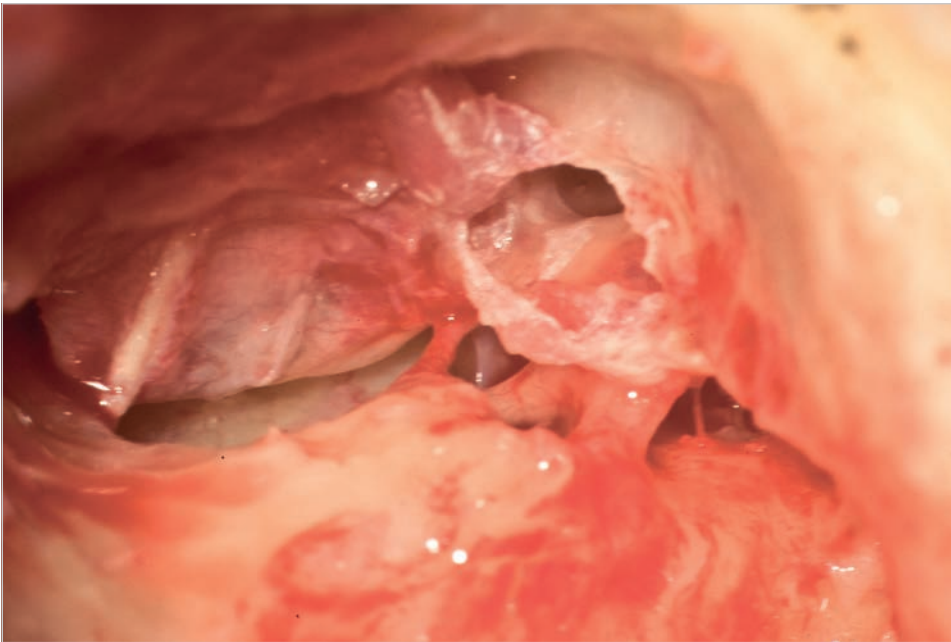


Fig. 7.268 The posterior buttress is removed. Access to the anterior part of cholesteatoma is impeded with bone covering it.



Fig. 7.269 The bone covering the anterior attic is partially removed. Since the anterior extension of cholesteatoma is too deep for postoperative cleaning, the matrix in the supratubal recess should be removed.

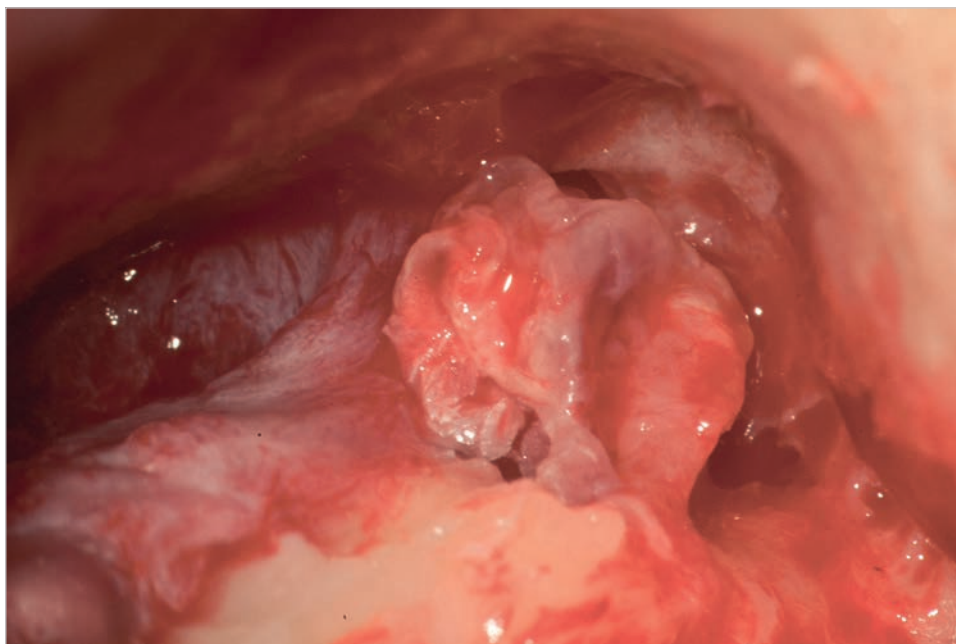


Fig. 7.270 The matrix covering the ossicular chain is detached, and reflected inferiorly.

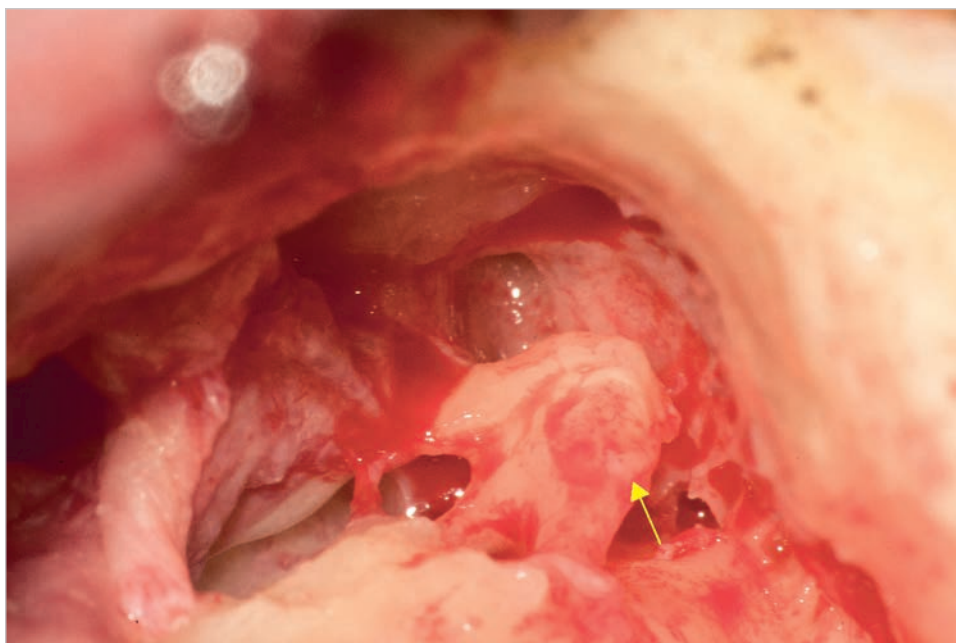


Fig. 7.271 The cholesteatoma is eradicated from the attic. Mild erosion is seen in the body of the incus (*arrow*).

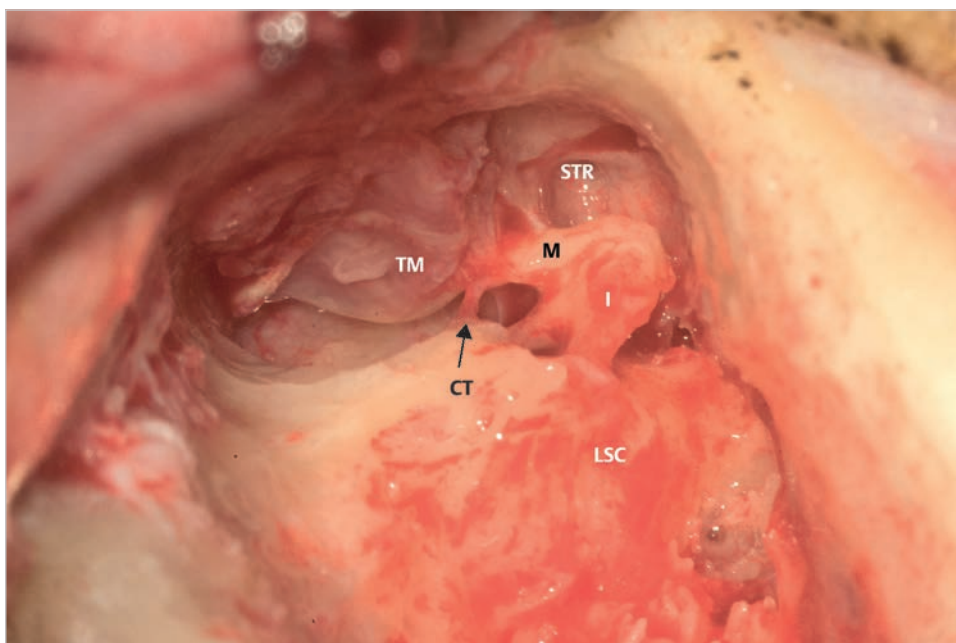


Fig. 7.272 Status of the canal wall down cavity after removal of the cholesteatoma is shown. The healthy chorda tympani nerve is preserved (*arrow*). CT, chorda tympani; I, body of incus; LSC, lateral semicircular canal; M, head of the malleus; STR, supratubal recess; TM, tympanic membrane.

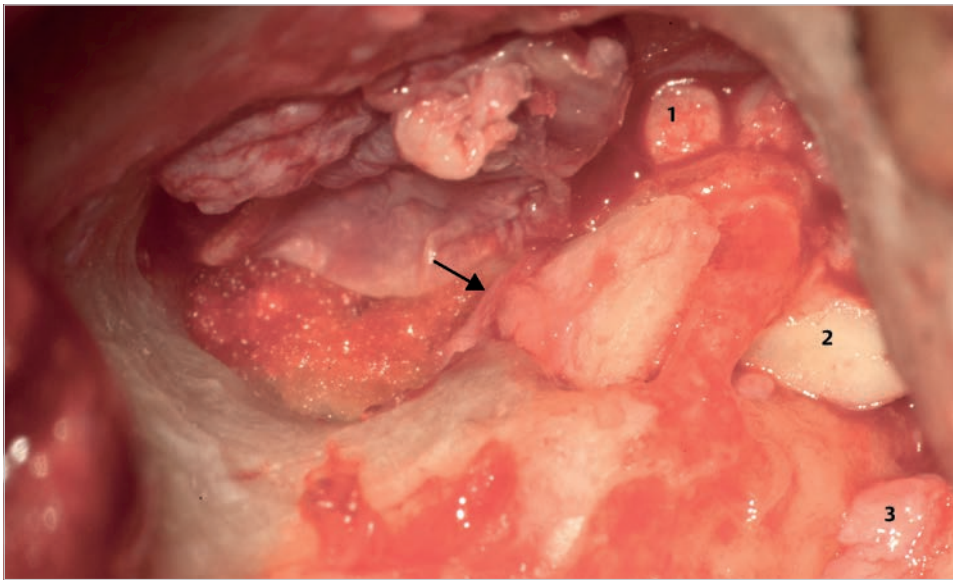


Fig. 7.273 The tympanic cavity is packed with pieces of Gelfoam. The posterosuperior quadrant is reinforced with a piece of cartilage. In this case, the cartilage is placed under the chorda tympani nerve (*black arrow*). The supratubal recess (1), the space medial to the ossicular chain (2), and the labyrinthine cells (3) are obliterated with pieces of cartilage.

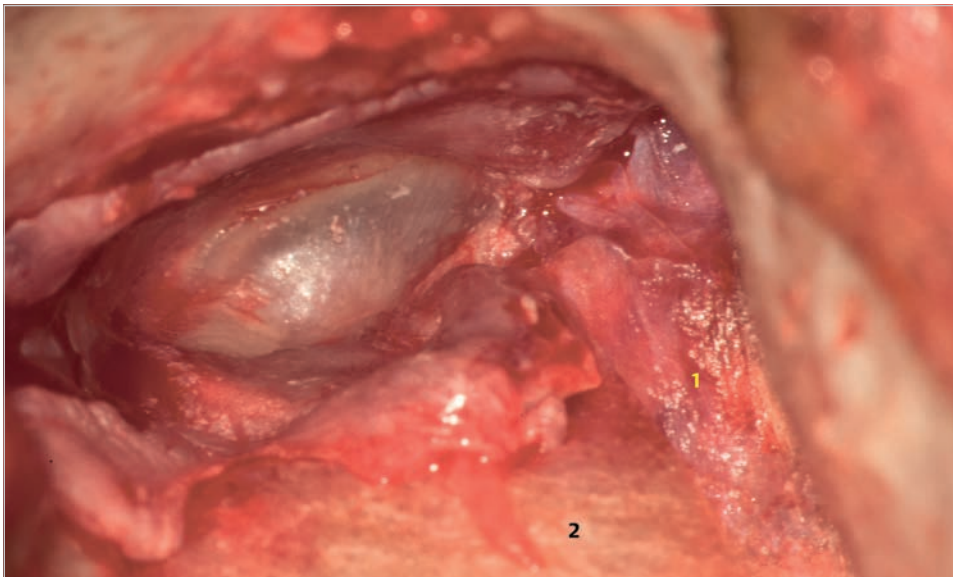


Fig. 7.274 Two pieces of fascia are used to cover the cavity. A thin string (1) is placed over the obliterated medial wall of the attic and under the body of the incus. Second piece (2) is placed under the tympanic membrane. This is an alternative technique to a large fascia with a cut passing the incus. The tympanomeatal flap is replaced over these fasciae.

Case 7.18 (Left Ear)

See ► Fig. 7.275, ► Fig. 7.276, ► Fig. 7.277, ► Fig. 7.278, ► Fig. 7.279, ► Fig. 7.280, ► Fig. 7.281, ► Fig. 7.282, ► Fig. 7.283, ► Fig. 7.284, ► Fig. 7.285, ► Fig. 7.286.



Fig. 7.275 A case of epitympanic cholesteatoma with a large erosion in the pars flaccida (*arrow*). Canal wall down mastoidectomy is started to open the antrum filled with cholesteatoma (Ch).

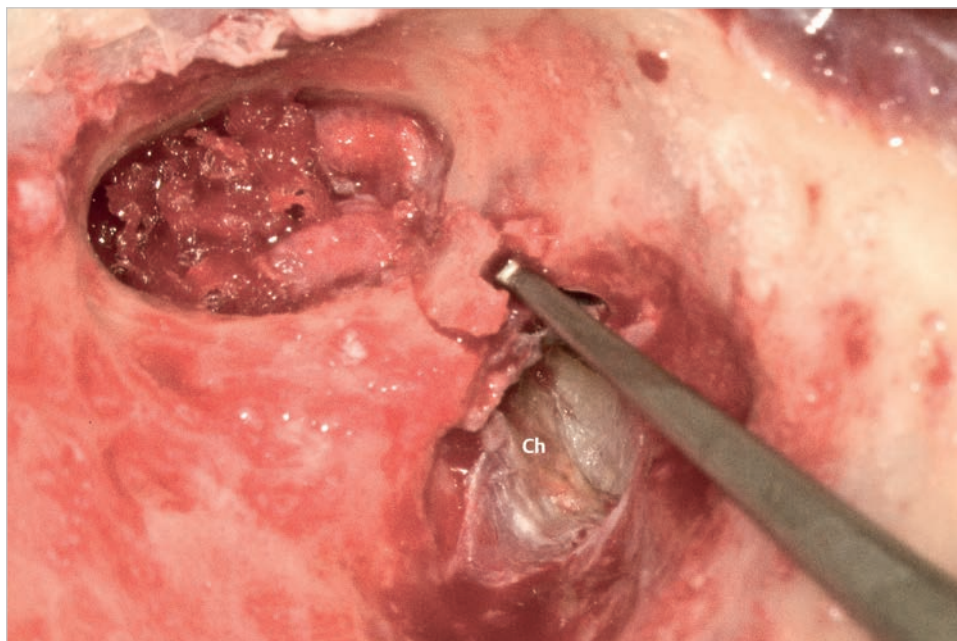


Fig. 7.276 The final bone near the ossicular chain is safely removed with a curette. Ch, cholesteatoma.

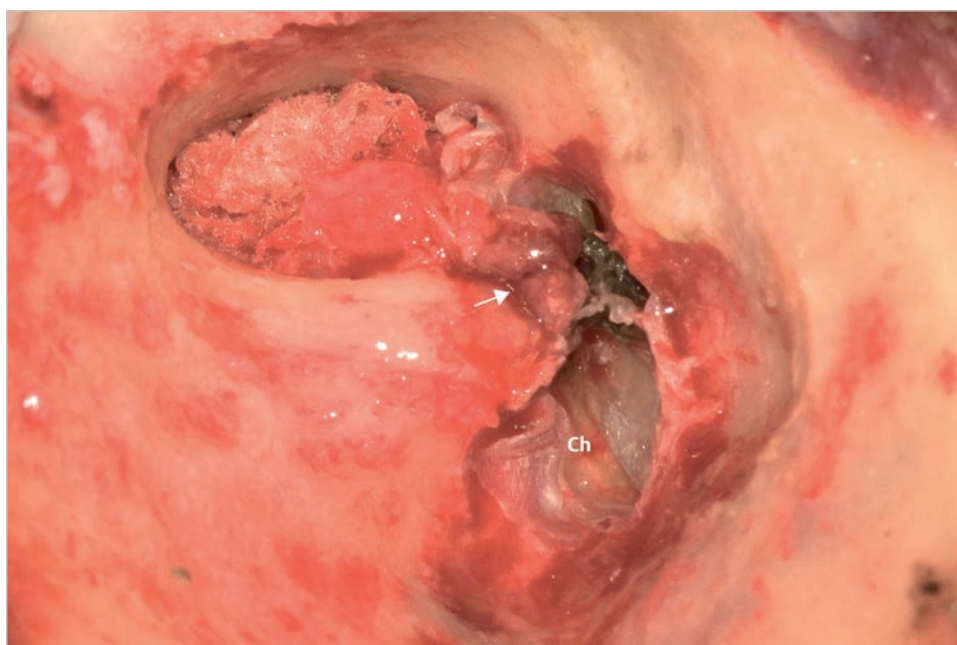


Fig. 7.277 The matrix is opened. Some granulation tissue and accumulated debris are seen near the orifice of cholesteatoma (*arrow*). Ch, cholesteatoma.

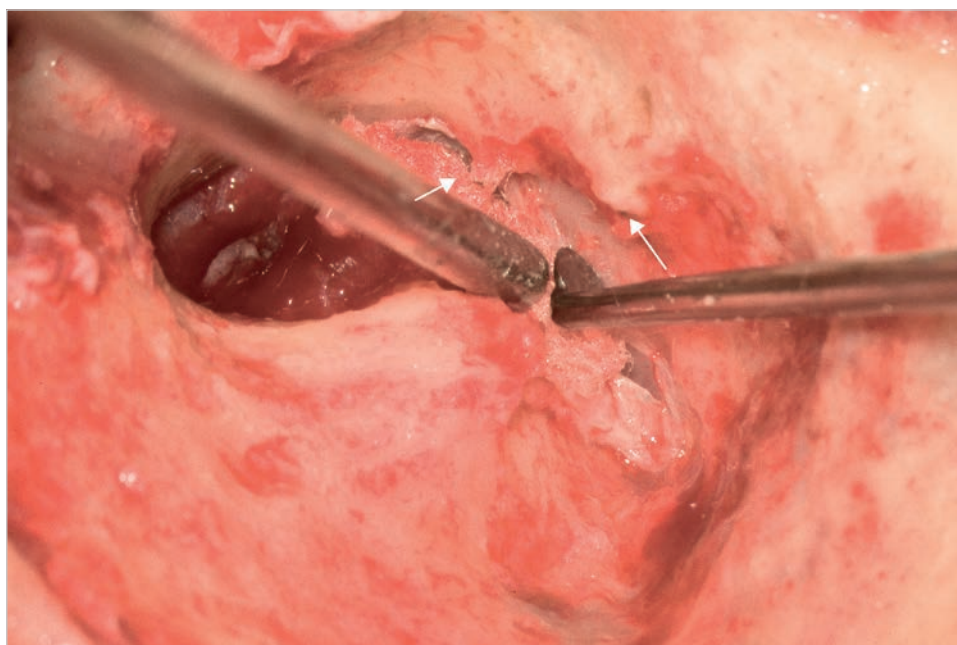


Fig. 7.278 The matrix covering the tegmen of the attic is dissected with the help of cottonoid. A bony ridge (*arrows*) left on the middle fossa plate at this moment should be removed to fully open the attic.

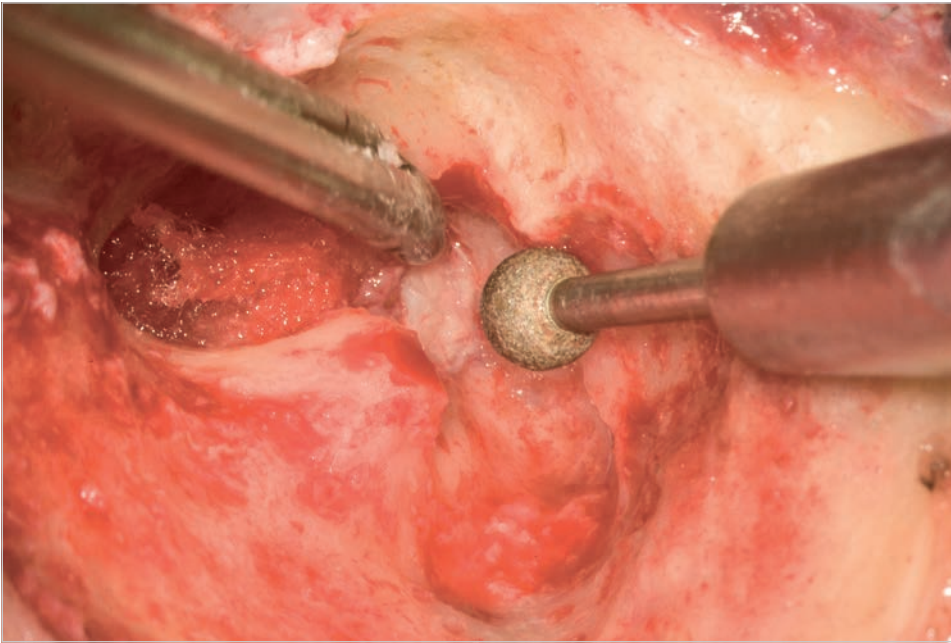


Fig. 7.279 The bony ridge is removed with a large diamond burr. The burr can be used in this particular case, since distance to the ossicular chain is large enough due to severe erosion of the superior part of it.

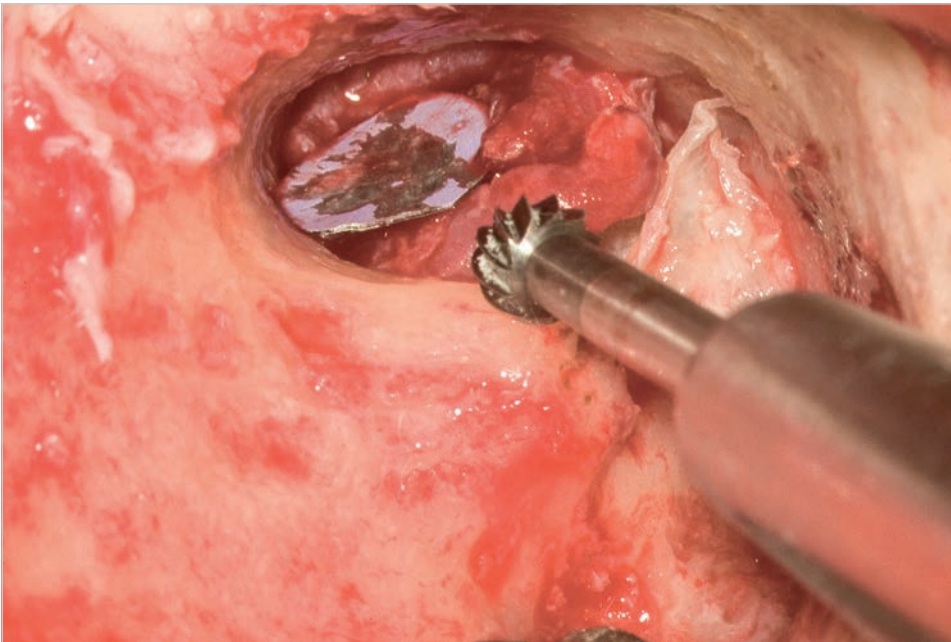


Fig. 7.280 The facial ridge is lowered with a cutting burr to reach the level of the bony annulus.

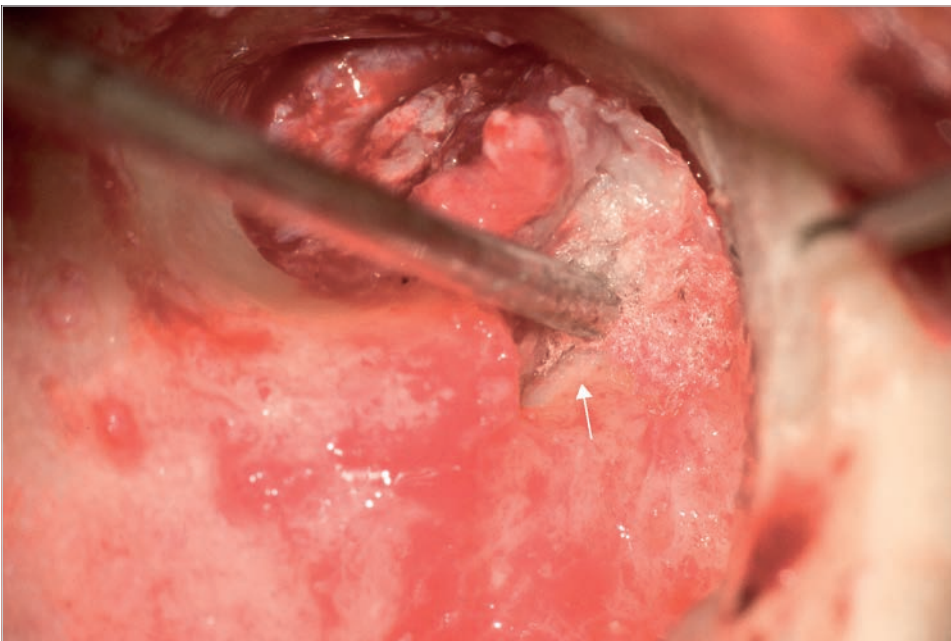


Fig. 7.281 The matrix is carefully dissected from the medial wall of the attic. The tympanic segment of the facial nerve is identified (*arrow*).



Fig. 7.282 The facial ridge is further lowered to obtain a round-shaped cavity.



Fig. 7.283 The facial ridge is sufficiently lowered. Note the smooth continuity of the facial ridge to the facial nerve.

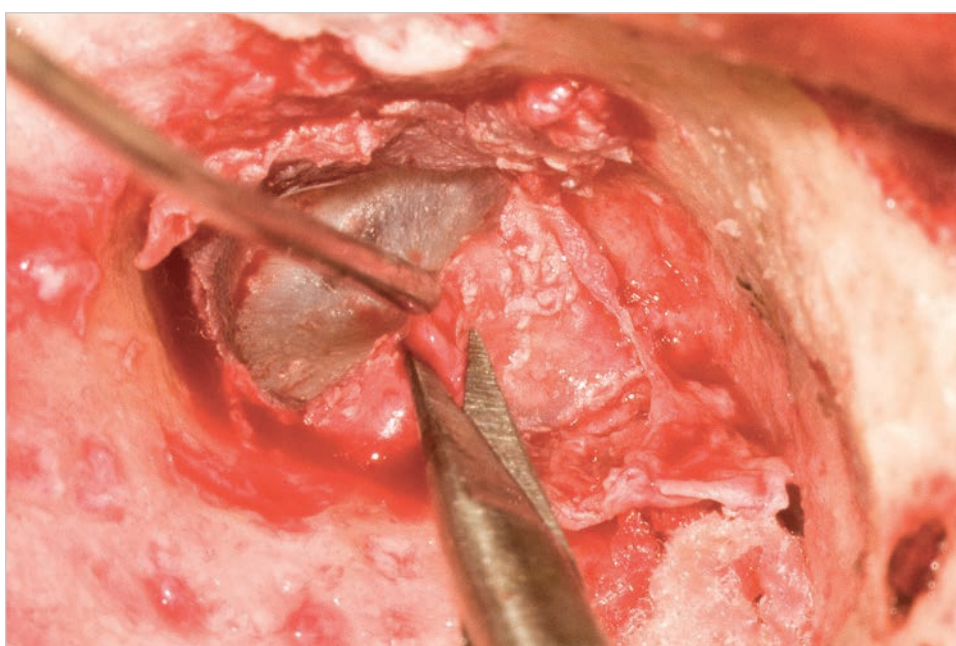


Fig. 7.284 A skin fold and granulation tissue formed at the orifice of cholesteatoma is cut off.

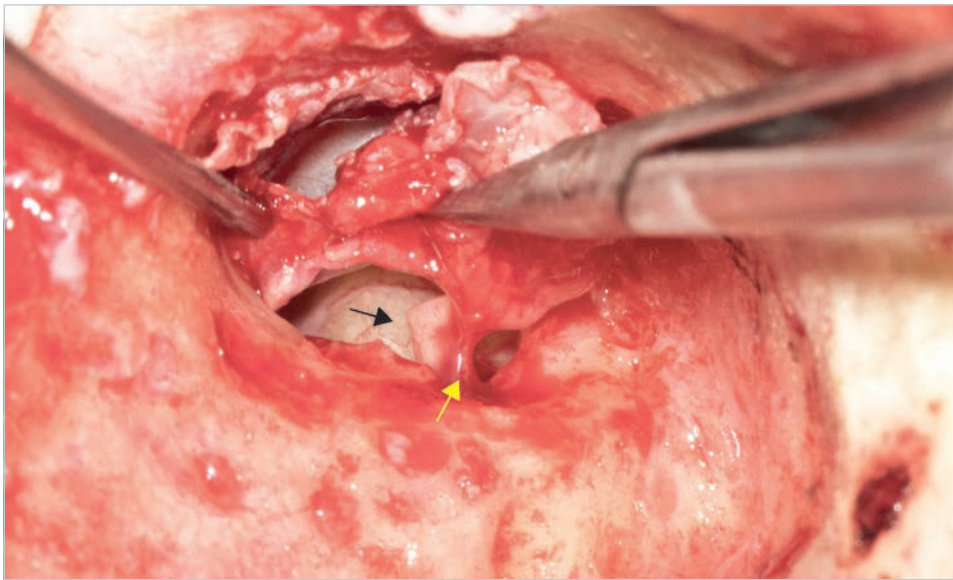


Fig. 7.285 The tympanomeatal flap is elevated and the tympanic cavity is opened to verify both absence of cholesteatoma, and continuity of the ossicular chain. The chorda tympani nerve (*yellow arrow*) and the incudostapedial joint (*black arrow*) are identified. Even though the majority of the ossicular chain in the attic is lost, continuity of the ossicular chain is maintained by a small remnant of the incudomalleolar joint. A piece of cartilage is placed under the posterosuperior quadrant to prevent retraction.

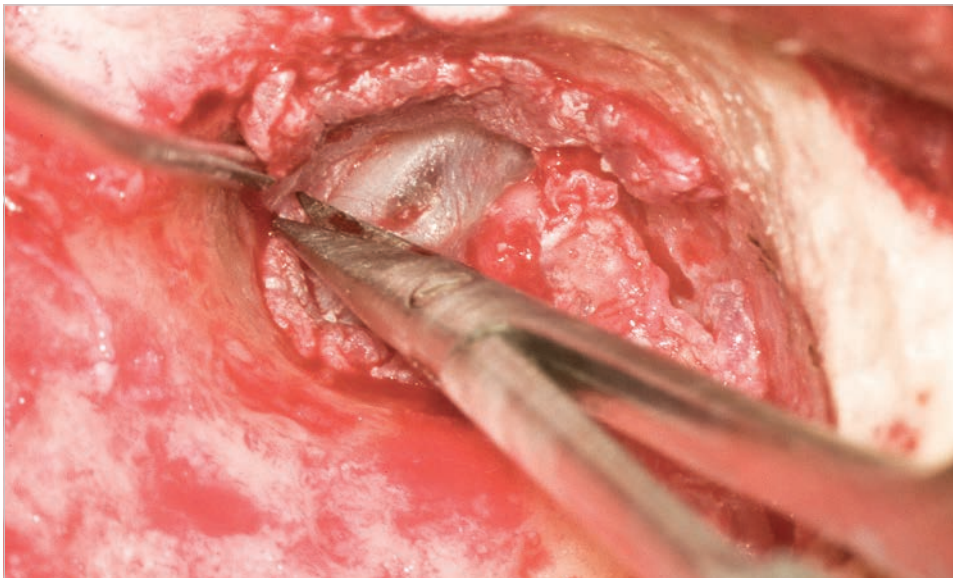


Fig. 7.286 The inferior meatal skin is incised for intimate attachment to the enlarged meatal wall.

Case 7.19 (Left Ear)

See ► Fig. 7.287, ► Fig. 7.288, ► Fig. 7.289, ► Fig. 7.290, ► Fig. 7.291, ► Fig. 7.292, ► Fig. 7.293, ► Fig. 7.294, ► Fig. 7.295, ► Fig. 7.296, ► Fig. 7.297, ► Fig. 7.298, ► Fig. 7.299.

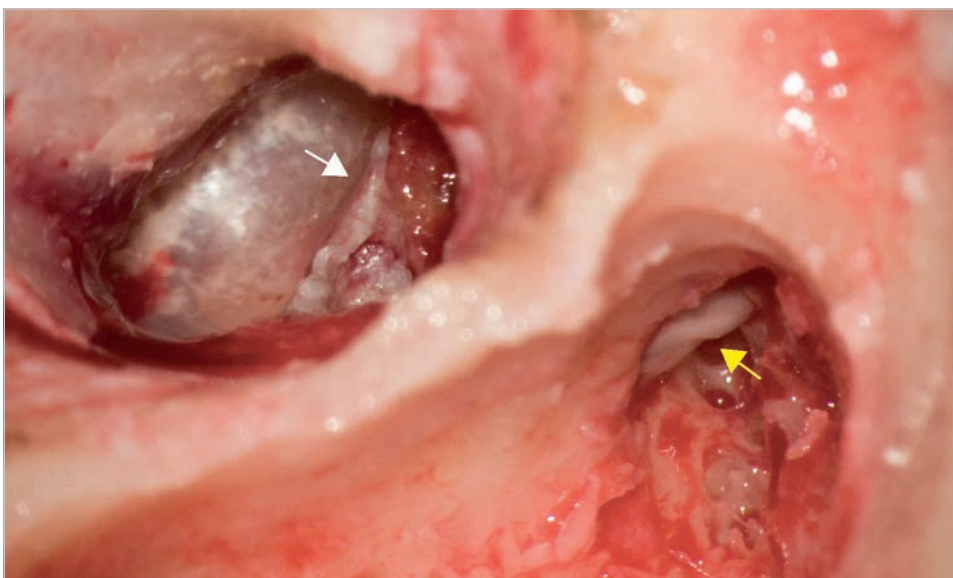


Fig. 7.287 A case of small cholesteatoma in the contracted mastoid with intact ossicular chain is shown. A large erosion with granulation tissue is seen in the pars flaccida of the tympanic membrane (*white arrow*). The mastoidectomy has been carried out to see the superoposterior end of the matrix (*yellow arrow*).

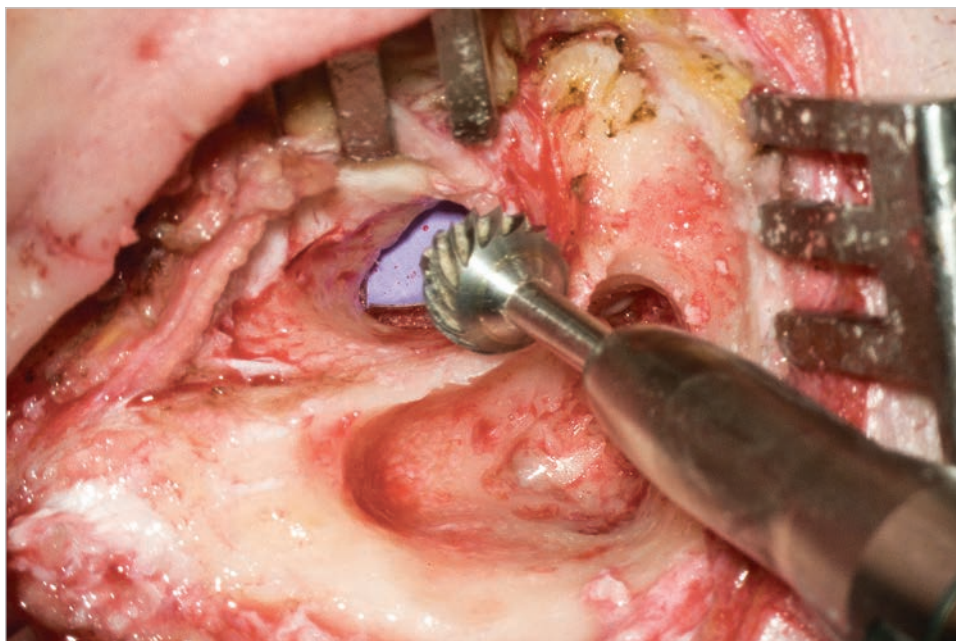


Fig. 7.288 To calibrate the external auditory canal, the meatal skin is detached and protected with an aluminum sheeting. The posterior wall is removed with a large cutting burr taking care not to touch the ossicular chain.



Fig. 7.289 Drilling of the posterior wall is advanced medially. Note that the cavity is well saucerized by removing all the cavity edges.

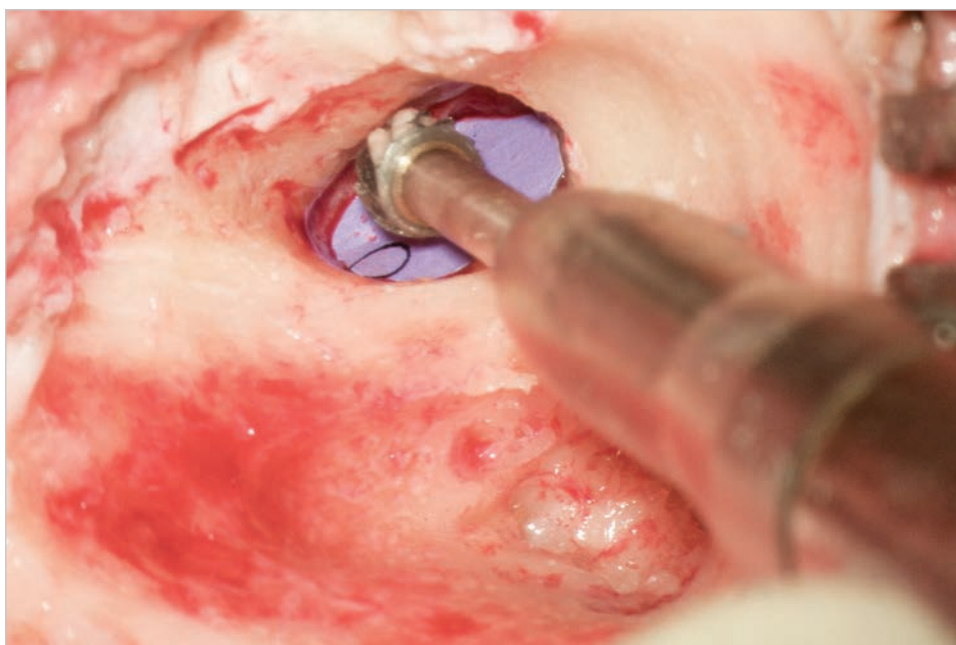


Fig. 7.290 The bony protrusion on the anterior meatal wall is removed with a cutting burr. The tympanomeatal flap should be protected with an aluminum sheeting during this procedure.

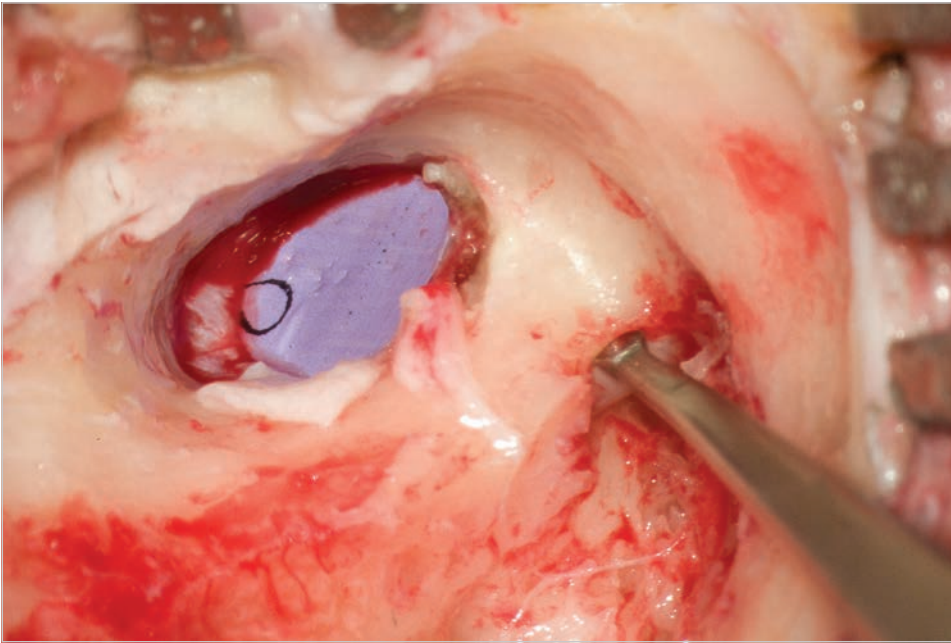


Fig. 7.291 The bone covering the attic can be removed with a curette. The procedure is a safer choice than using a drill when working around the intact ossicular chain.

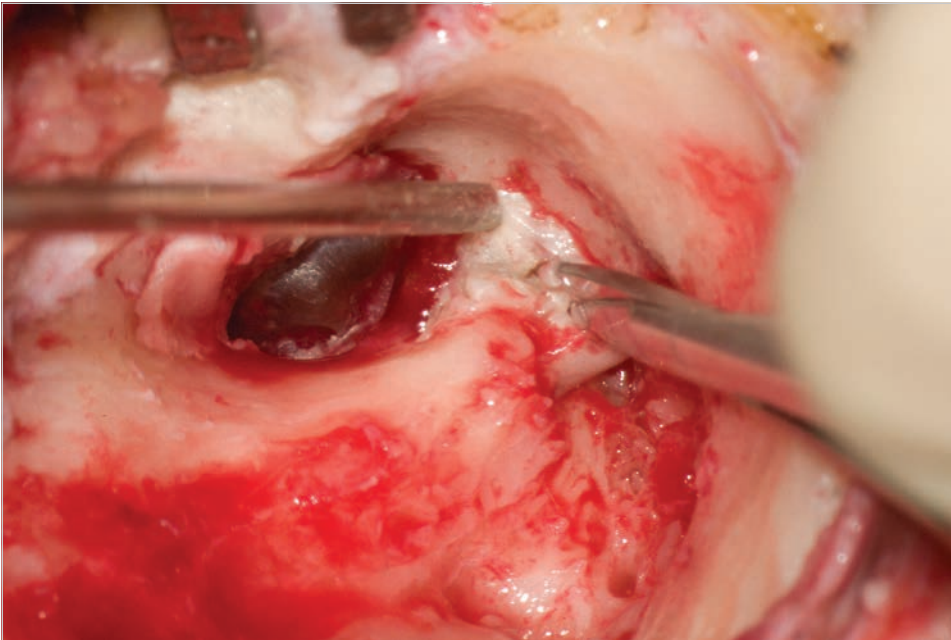


Fig. 7.292 The bone covering the lateral face of the cholesteatoma is removed. Exposure of the lateral face allows debulking of cholesteatoma that facilitates dissection of the matrix from the ossicular chain.



Fig. 7.293 Evacuation of debris in the cholesteatoma visualized the ossicular chain covered with granulation tissue (*arrow*). Localization of the ossicular chain as early as possible in the middle ear is very important to avoid insulting it.

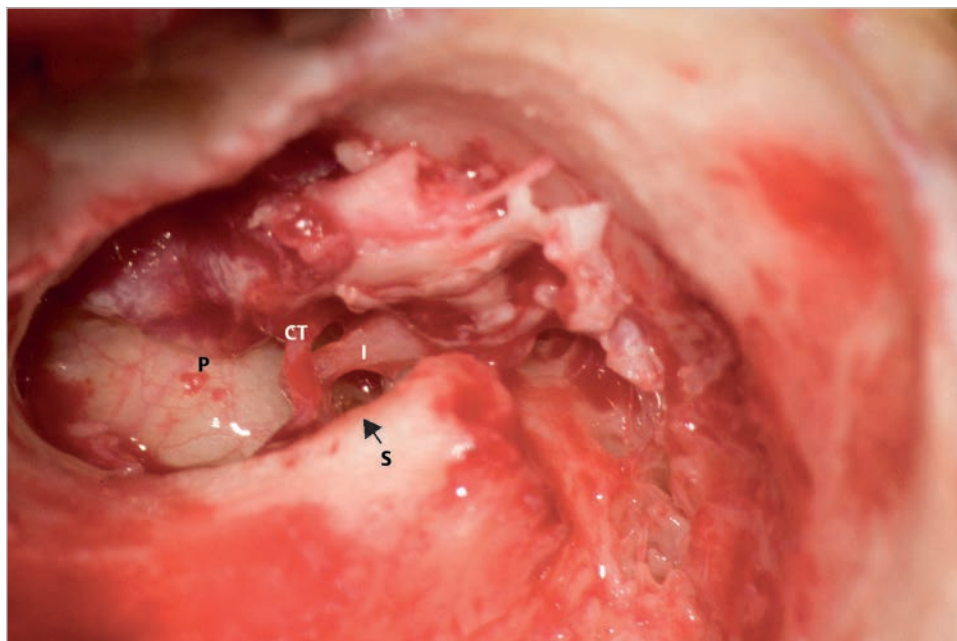


Fig. 7.294 The tympanic cavity is opened from inferior to superior to visualize the inferior pole of the cholesteatoma in the tympanic cavity. The matrix covering the ossicular chain is reflected anteriorly, and is dissected from the incus. CT, chorda tympani; I, incus; P, promontory; S, stapes.

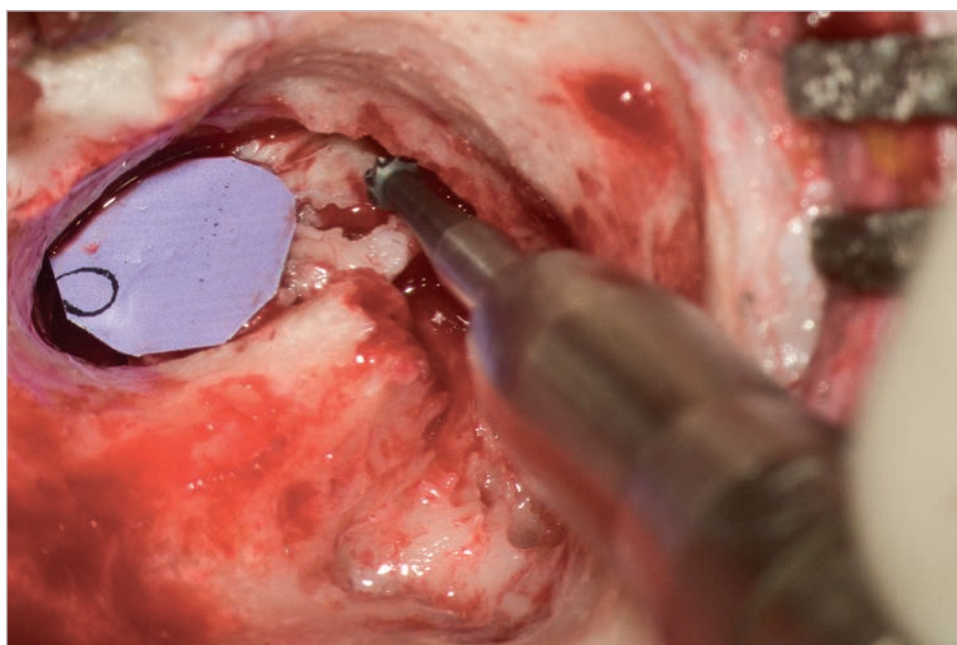


Fig. 7.295 The bony overhang impeding access to the anterosuperior part of the cholesteatoma is removed with a small cutting burr. The burr head should not be pushed against the tegmen to avoid damaging the dura. Movement of the burr in this area should be either from medial to lateral or parallel to the ossicular chain to avoid insulting it.

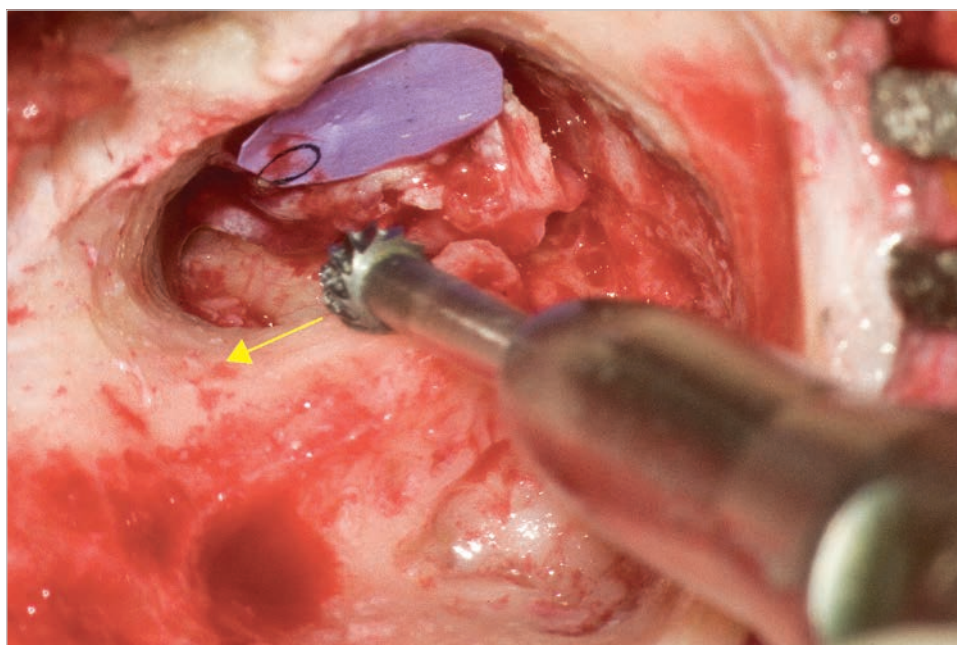


Fig. 7.296 The facial ridge is lowered to the level of the chorda tympani nerve to achieve a round-shaped, trouble-free cavity. Care should be taken in this procedure not to insult the short process of the incus. To reduce such risk, the drill should be moved parallel to the facial ridge, from the area near the incus to inferior (arrow).

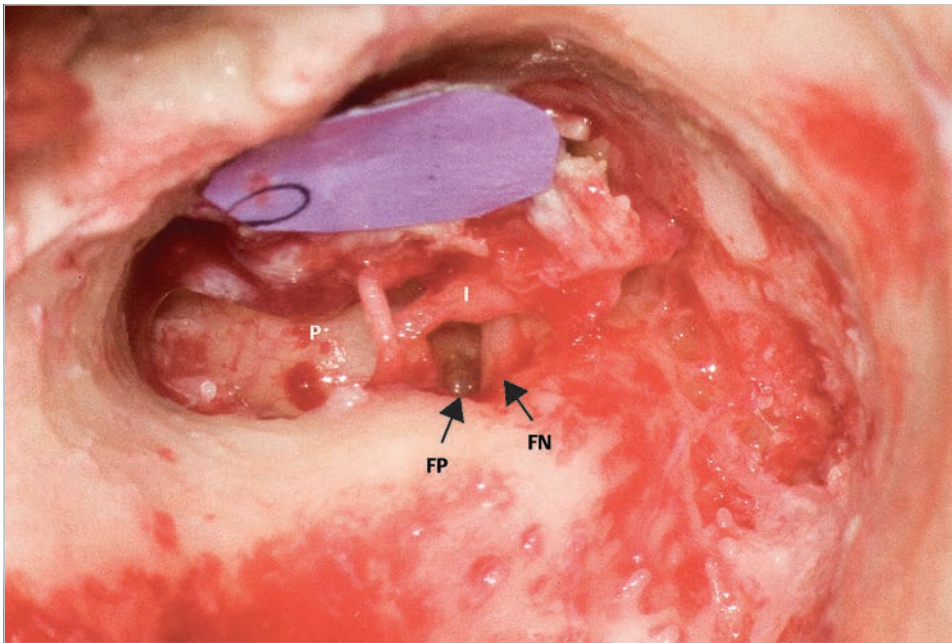


Fig. 7.297 Lowering of the facial ridge rounded the cavity and visualized the structures around the incudostapedial joint. FN, facial nerve; FP, footplate; I, incus; P, promontory.

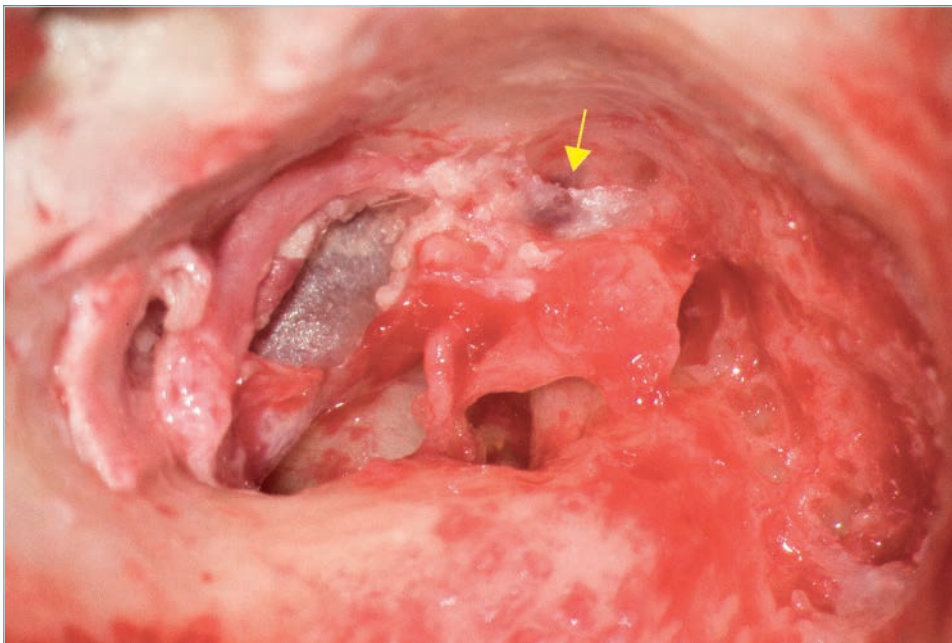


Fig. 7.298 The body of the incus is heavily eroded, but continuity of the ossicular chain is preserved. The skin forming shallow dimple anteriorly to the ossicular chain (*arrow*) is left in place since the area is cleanable and the skin is not inflamed.

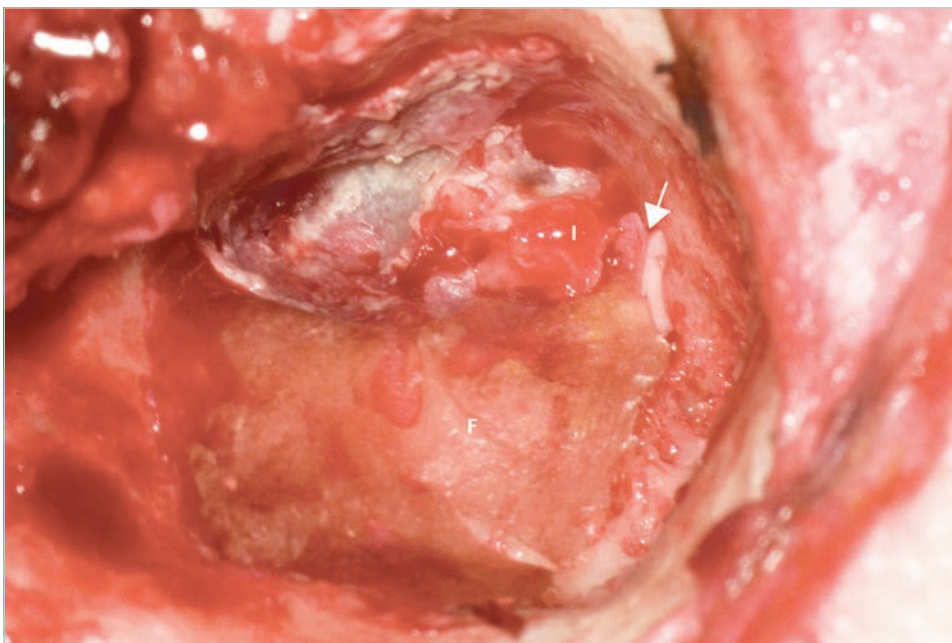


Fig. 7.299 The posterosuperior quadrant of the tympanic membrane is reinforced with a piece of cartilage. The space medially to the ossicular chain is obliterated with pieces of cartilage to avoid postoperative invagination (*white arrow*). A large piece of fascia is placed over the medial wall of the cavity, and the tympanic membrane is placed back on it. Note that the body of the incus is exteriorized through a cut in the fascia. F, fascia; I, incus.

Case 7.20 (Right Ear)

See ► Fig. 7.300, ► Fig. 7.301, ► Fig. 7.302, ► Fig. 7.303, ► Fig. 7.304, ► Fig. 7.305, ► Fig. 7.306, ► Fig. 7.307.

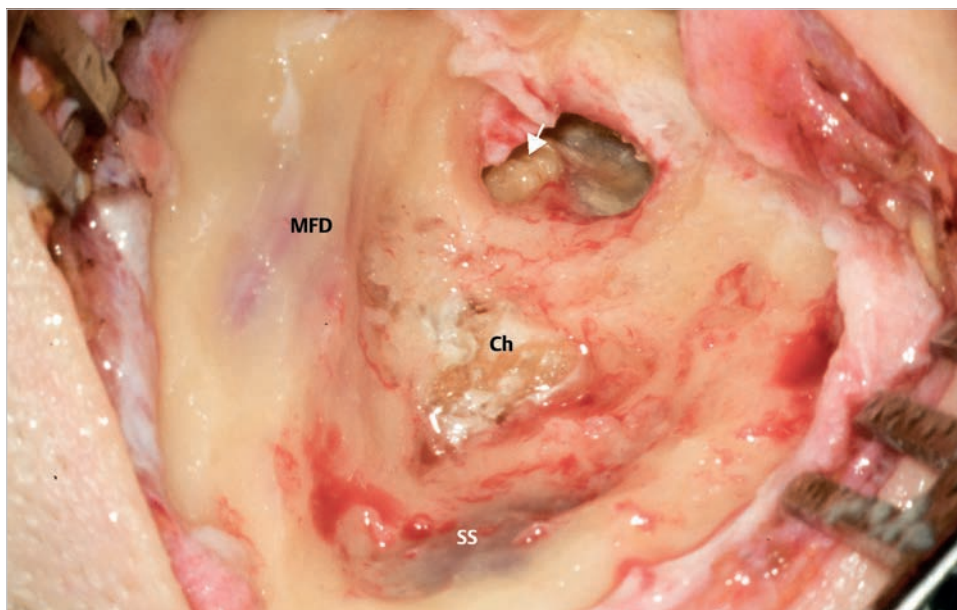


Fig. 7.300 A case of epitympanic cholesteatoma limited laterally to the ossicular chain with good hearing. A considerable bone erosion is identified in the pars flaccida (*arrow*). Note the saucerized wide opening with good skeletonization of the middle fossa plate superiorly and the sigmoid sinus posteriorly. Cholesteatoma filling the antrum is seen. Ch, cholesteatoma; MFD, middle fossa dura; SS, sigmoid sinus.

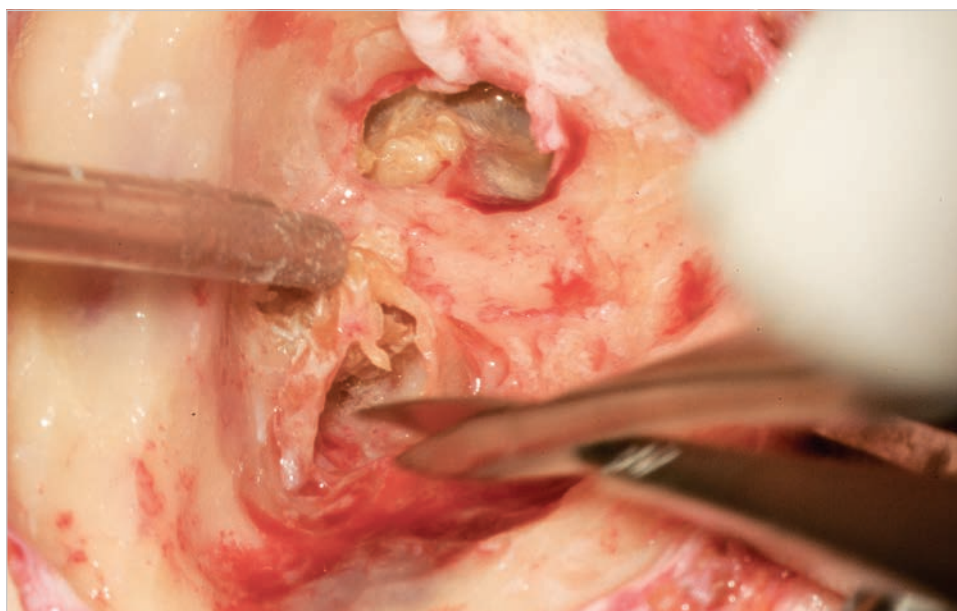


Fig. 7.301 Debris in the cholesteatoma is evacuated, and the matrix is reduced. The procedure facilitates dissection of the matrix from the lateral wall of the antrum, to permit drilling of the facial bridge.

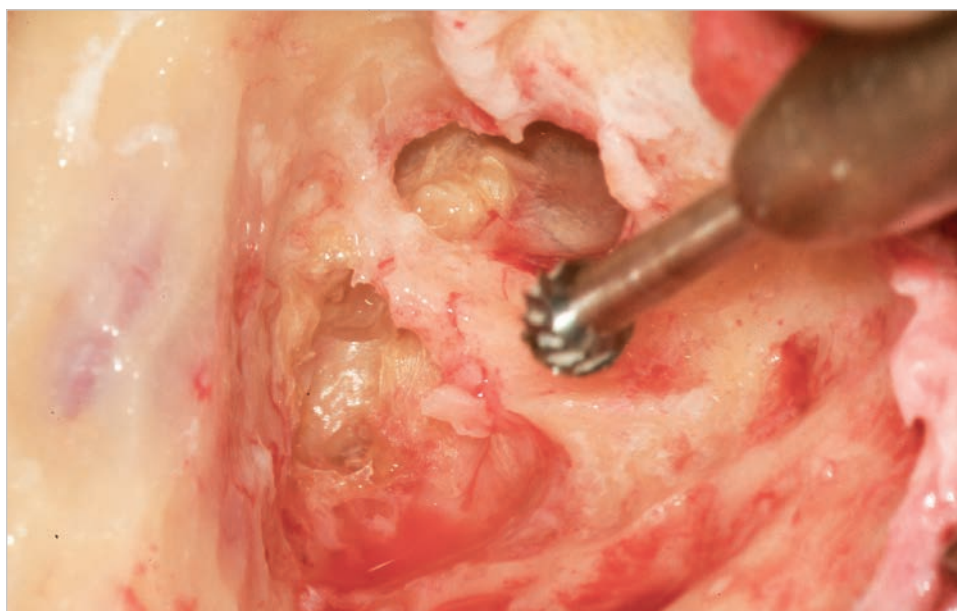


Fig. 7.302 The facial ridge is lowered, and the facial bridge covering the attic is removed to establish full access to the cholesteatoma. Great care should be taken not to touch the ossicular chain, especially when working around the area of the short process of the incus.

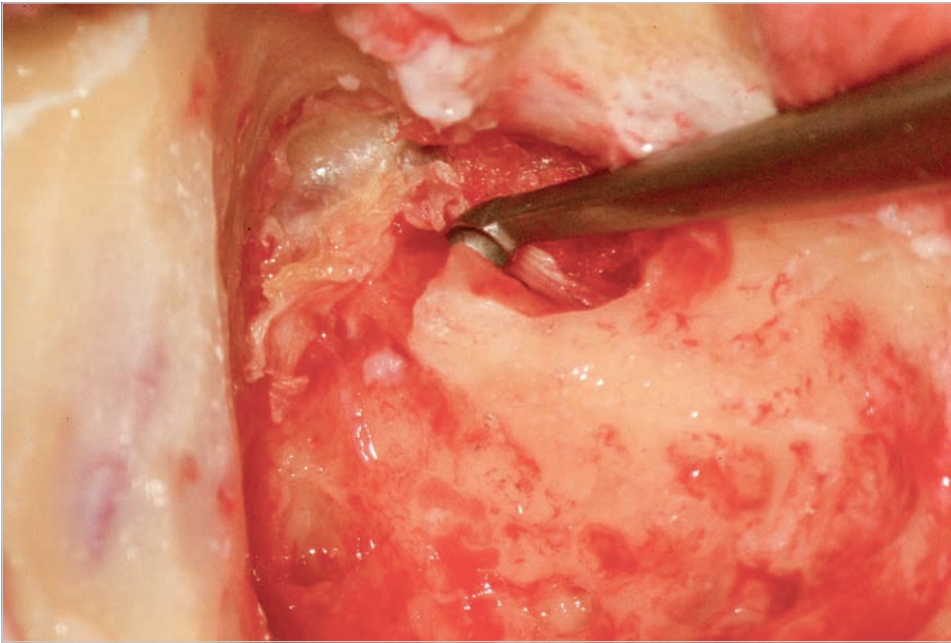


Fig. 7.303 The bone covering the fossa incudis is safely removed with a curette.

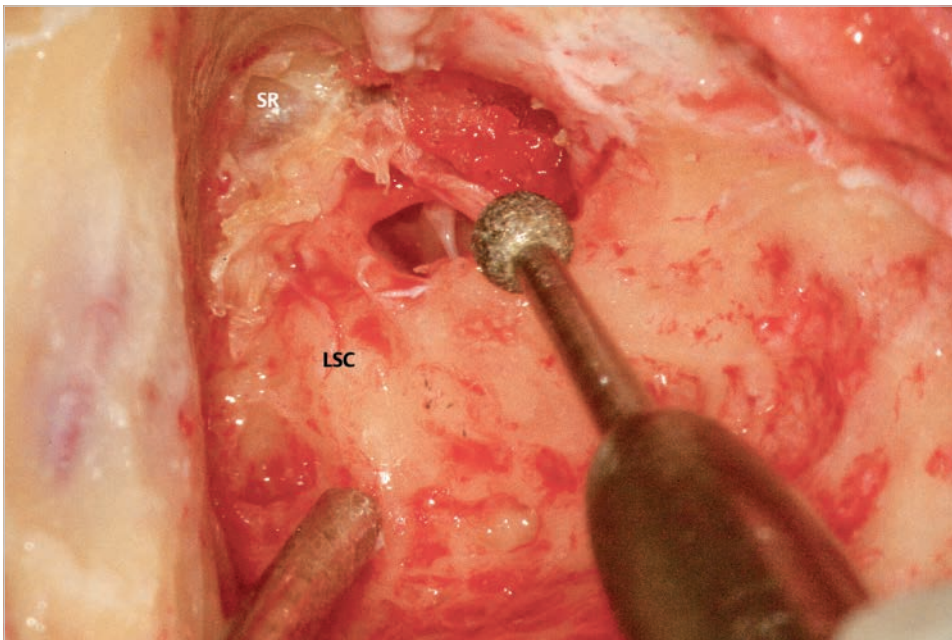


Fig. 7.304 The facial ridge is further lowered with a diamond burr taking care not to touch the short process of the incus. The matrix covers small supratubal recess located anteriorly to the head of the malleus. LSC, lateral semicircular canal; SR, supratubal recess.

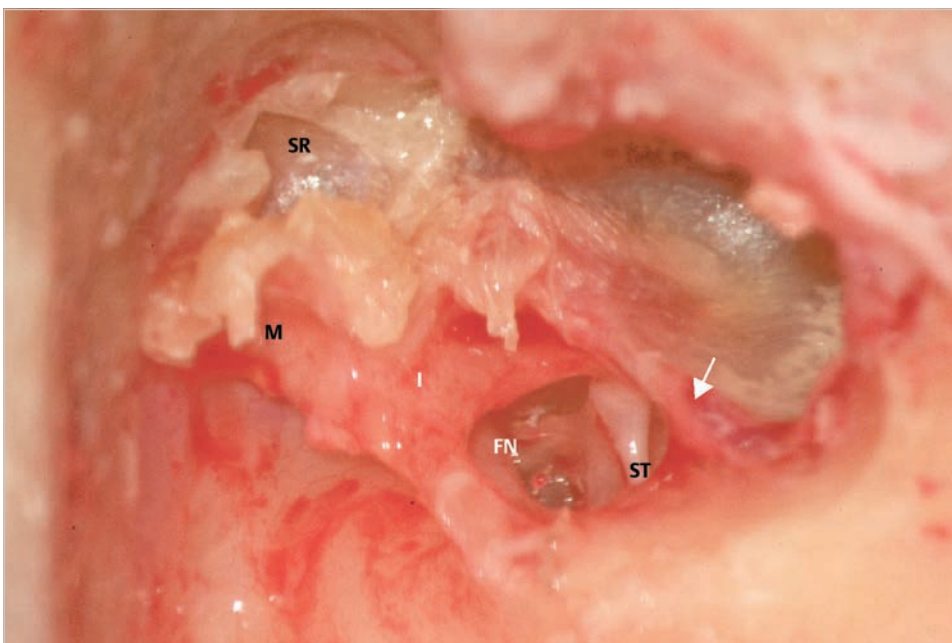


Fig. 7.305 The facial ridge is lowered in such way that it joins smoothly the tympanic segment of the facial nerve superiorly, and the external auditory canal anteriorly. The chorda tympani nerve pushed inferiorly is seen (arrow). FN, facial nerve; I, incus; M, malleus; ST, tendon of stapedial muscle; SR, supratubal recess.

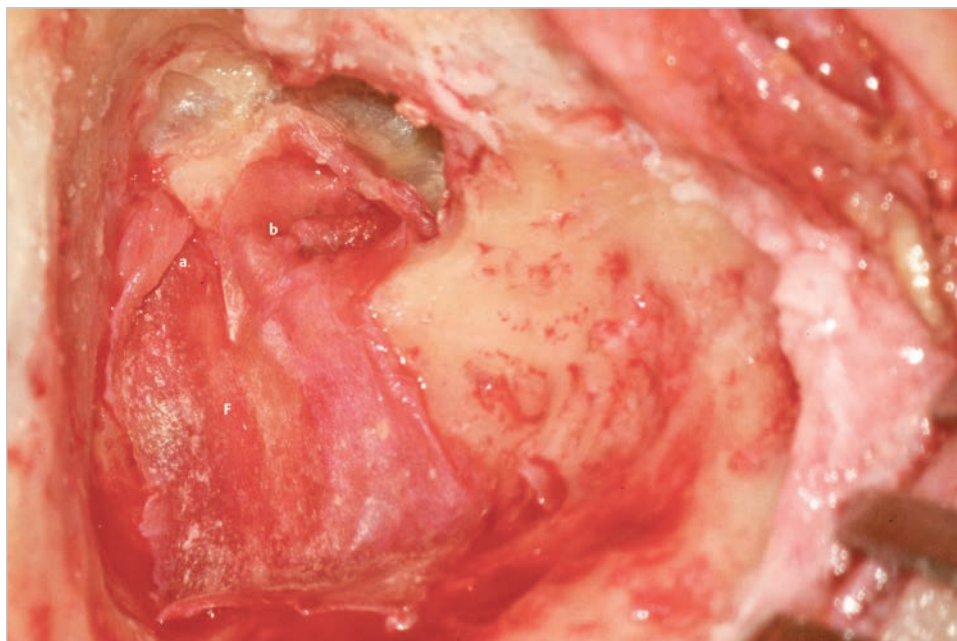


Fig. 7.306 The skin covering the shallow accessible supratubal recess is left in place, and a large piece of fascia with a cut is grafted underlay after obliterating the space between the medial wall of the attic and the ossicular chain with a small piece of cartilage. The superior tongue (a) is grafted under the body of the incus, and the inferior tongue (b) is grafted over the long process of the incus. F, fascia.

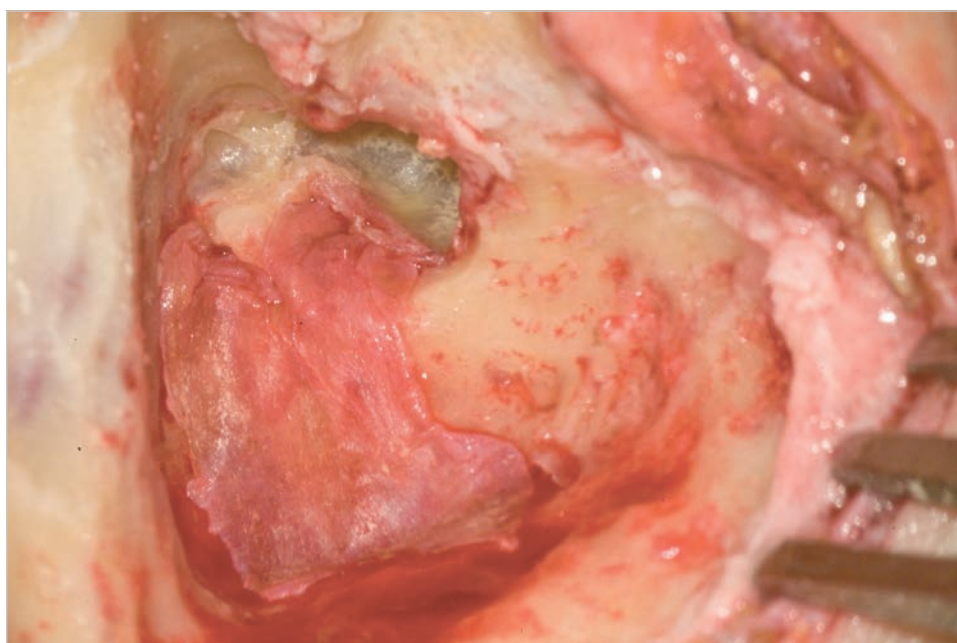


Fig. 7.307 The final shape of the cavity is shown. The posterosuperior quadrant of the tympanic membrane is reinforced with a piece of cartilage.

Case 7.21 (Left Ear)

See ► Fig. 7.308, ► Fig. 7.309, ► Fig. 7.310, ► Fig. 7.311, ► Fig. 7.312, ► Fig. 7.313, ► Fig. 7.314, ► Fig. 7.315, ► Fig. 7.316, ► Fig. 7.317, ► Fig. 7.318, ► Fig. 7.319, ► Fig. 7.320, ► Fig. 7.321, ► Fig. 7.322, ► Fig. 7.323, ► Fig. 7.324, ► Fig. 7.325.

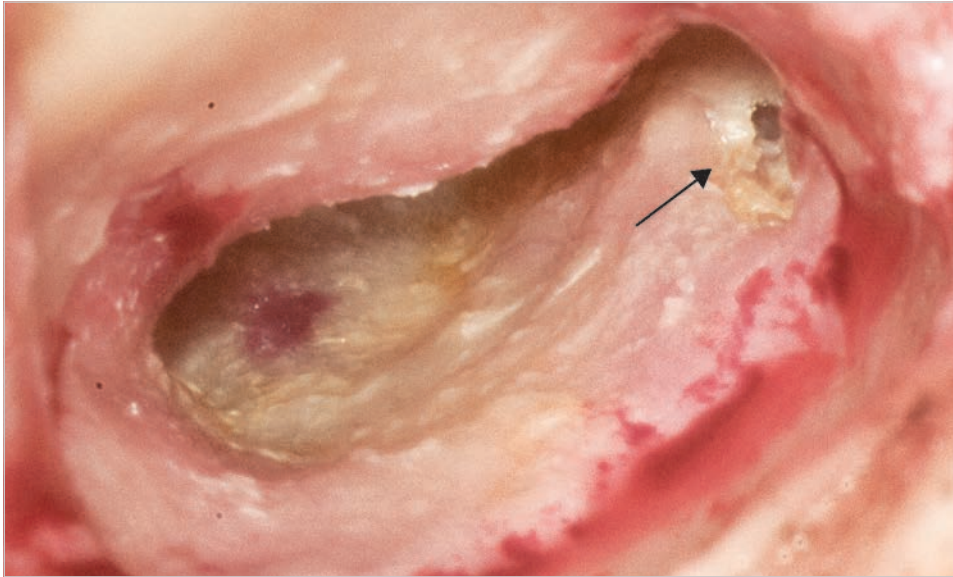


Fig. 7.308 A case of epitympanic cholesteatoma with small extension of posterosuperior mesotympanum is shown. The cholesteatoma entered the middle ear through a small erosion in the pars flaccida (arrow). Access to the tympanic membrane is narrowed by the protrusion of the anterior meatal wall.



Fig. 7.309 For both adequate exposure of cholesteatoma and proper postoperative care, the external auditory canal should be calibrated. A lateral circumferential incision is made in the anterior meatal skin for canaloplasty.

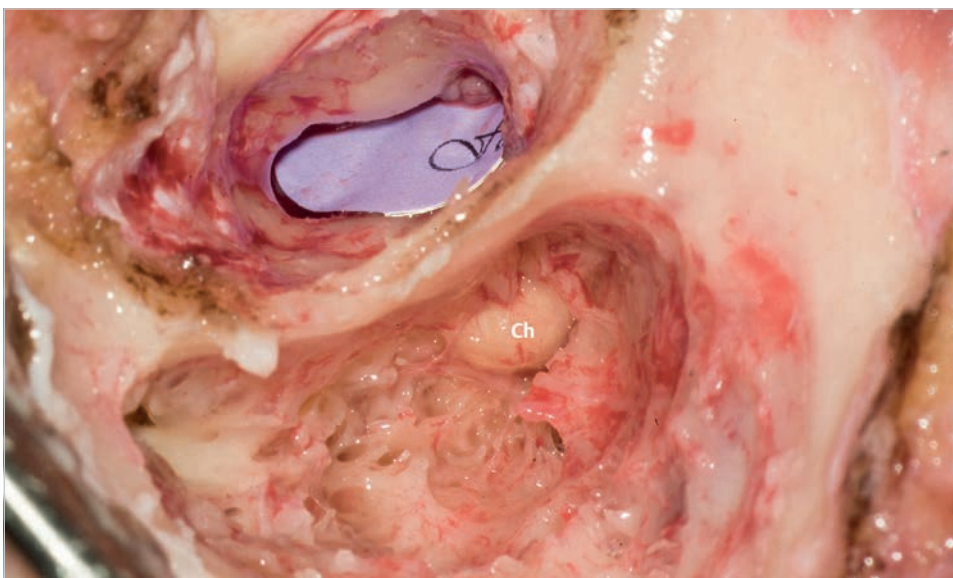


Fig. 7.310 Mastoidectomy is carried out to expose the posterior pole of the cholesteatoma (Ch) protruding to the antrum.

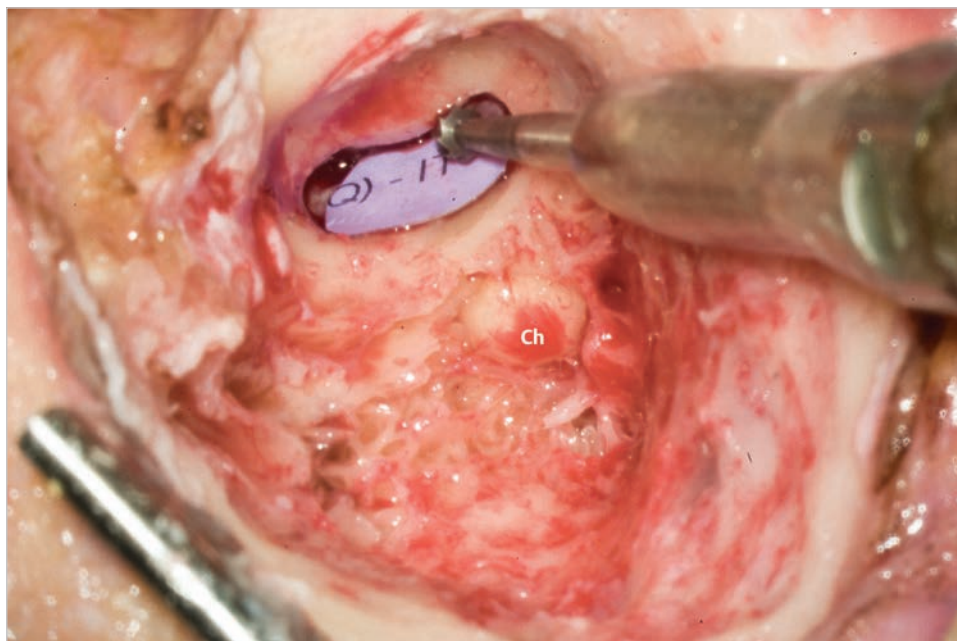


Fig. 7.311 Removal of the posterior wall is started. To improve access to the tympanic membrane including entrance of the cholesteatoma, the protrusion in the anterior wall of the bony meatus needs to be removed. Ch, cholesteatoma.

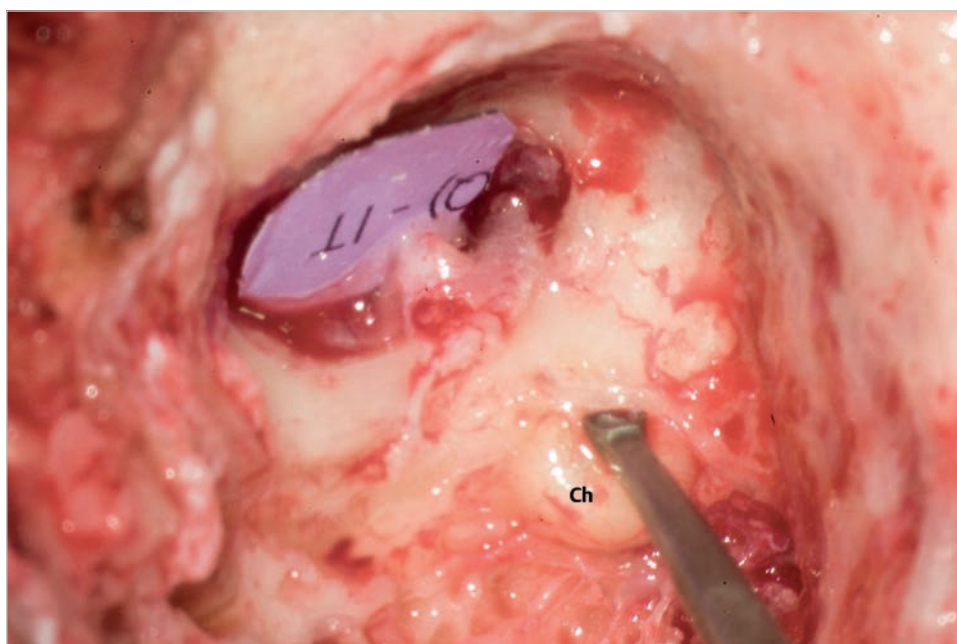


Fig. 7.312 Opening of the attic with burrs should be conducted with great care whenever continuity of the ossicular chain is preserved. The short process of the incus is located more lateral than the body, and accommodating in a very narrow fossa incudis where the lateral wall and the incus are extremely close. The final bony shell covering cholesteatoma in the attic can be removed safely with a curette, with a movement from medial to lateral. Ch, cholesteatoma.

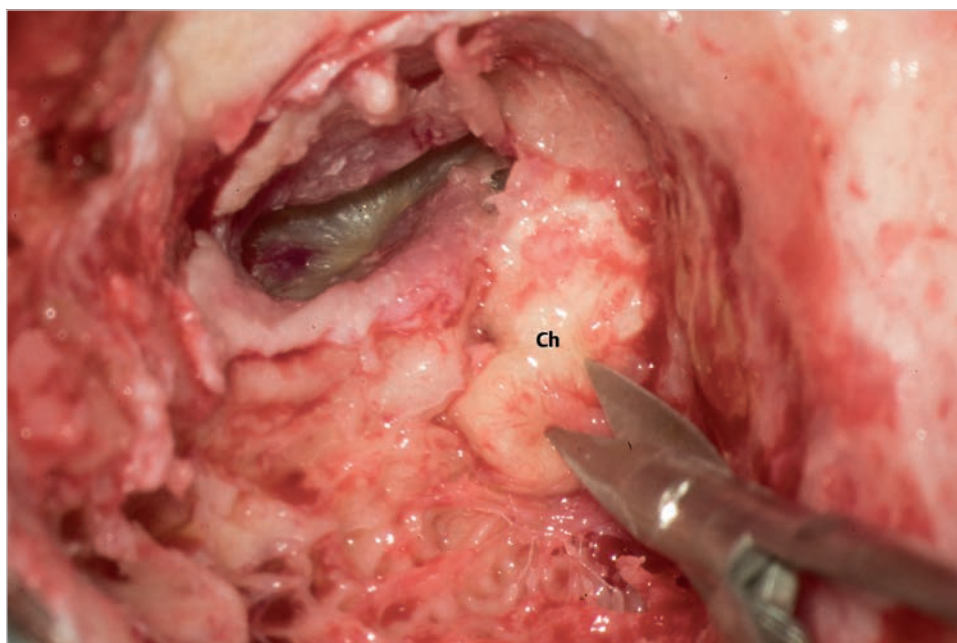


Fig. 7.313 For precise dissection of cholesteatoma matrix and safe drilling, debulking of cholesteatoma is very important. The matrix is incised, and the debris is evacuated from the inside. Ch, cholesteatoma.

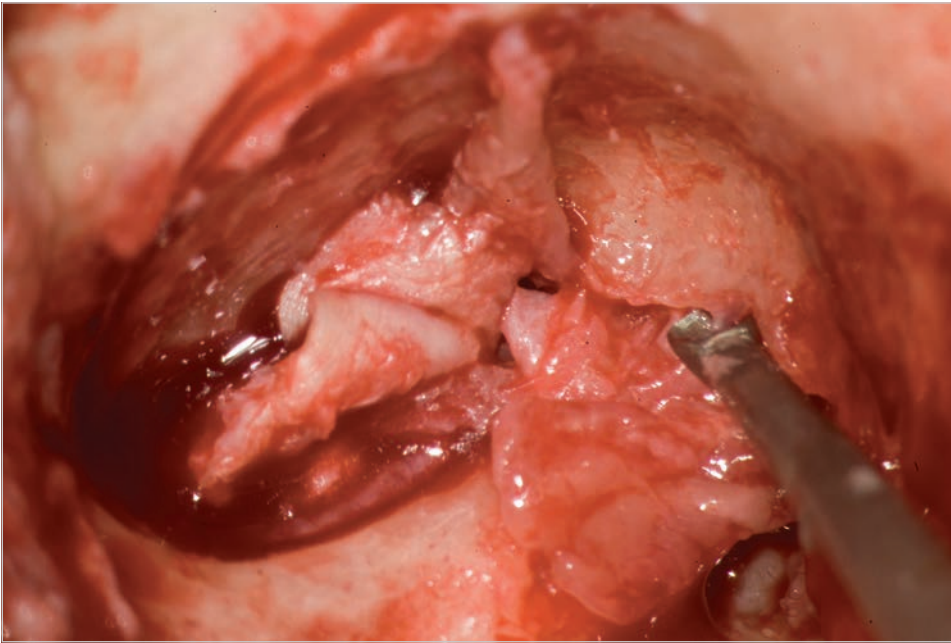


Fig. 7.314 Bone covering the ossicular chain is thinned with burrs, and the final bony overhang close to the chain can be removed with a curette.

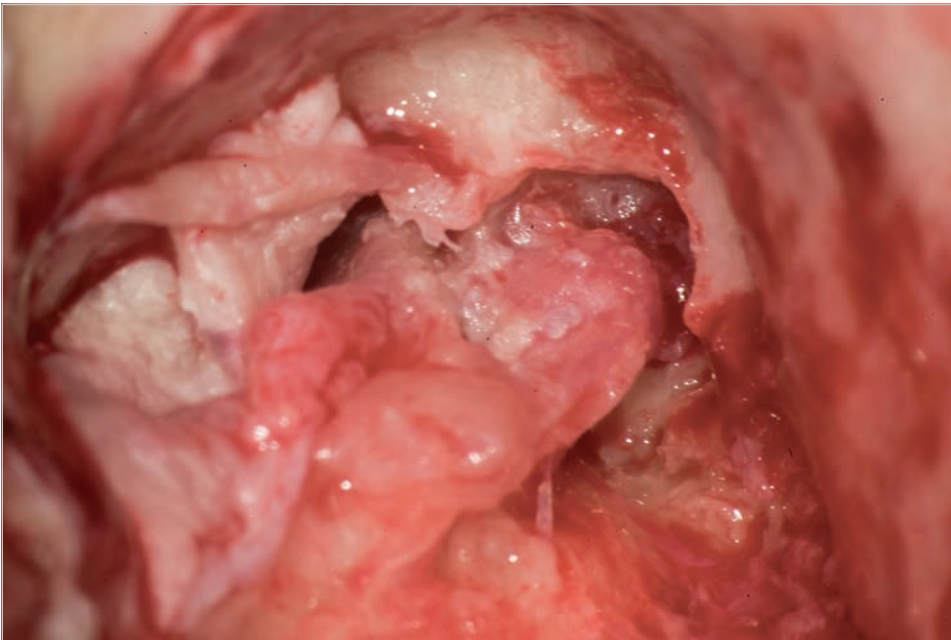


Fig. 7.315 The ossicular chain in the attic is visualized, and under control.

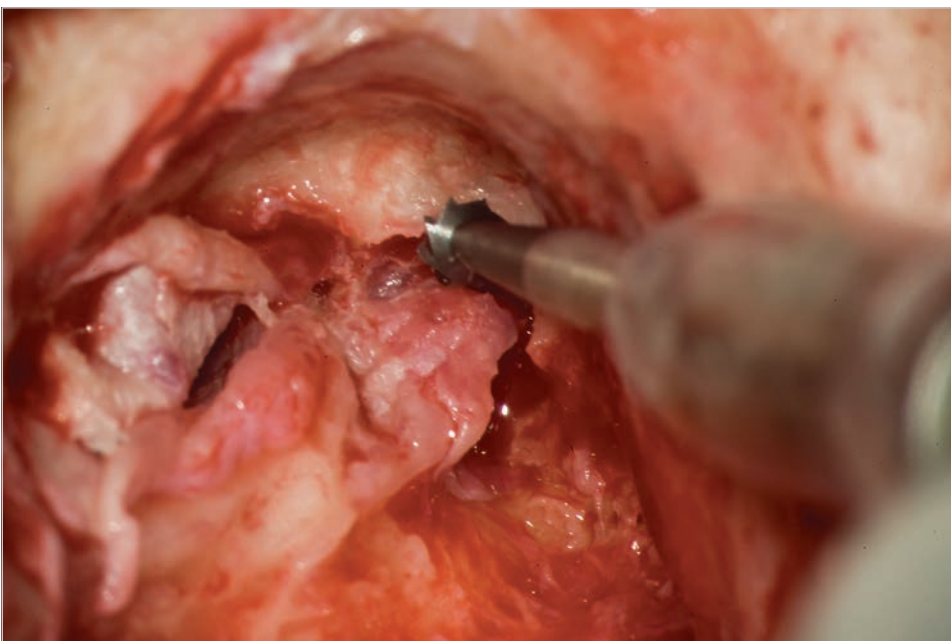


Fig. 7.316 The bony ridge covering the attic is flattened with a small cutting burr taking care not to touch the ossicles.

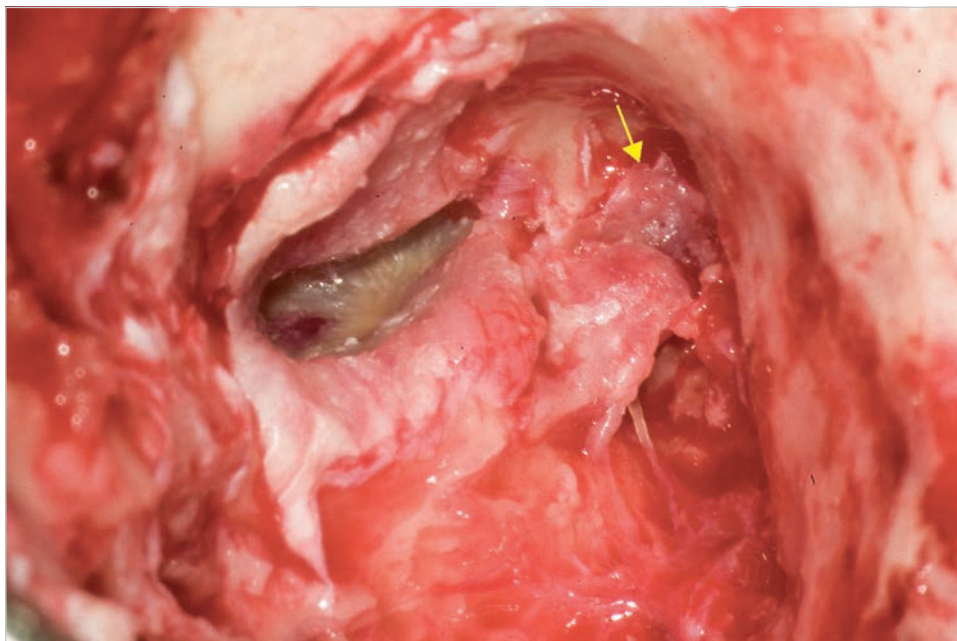


Fig. 7.317 The matrix covering the anterior wall of the attic is visualized (*arrow*).



Fig. 7.318 The cholesteatoma is dissected from the anterior wall and the ossicular chain.



Fig. 7.319 The cholesteatoma descends to the posterior mesotympanum through the space between the chorda tympani nerve and the long process of the incus. To establish access to that area, the facial ridge should be sufficiently lowered.

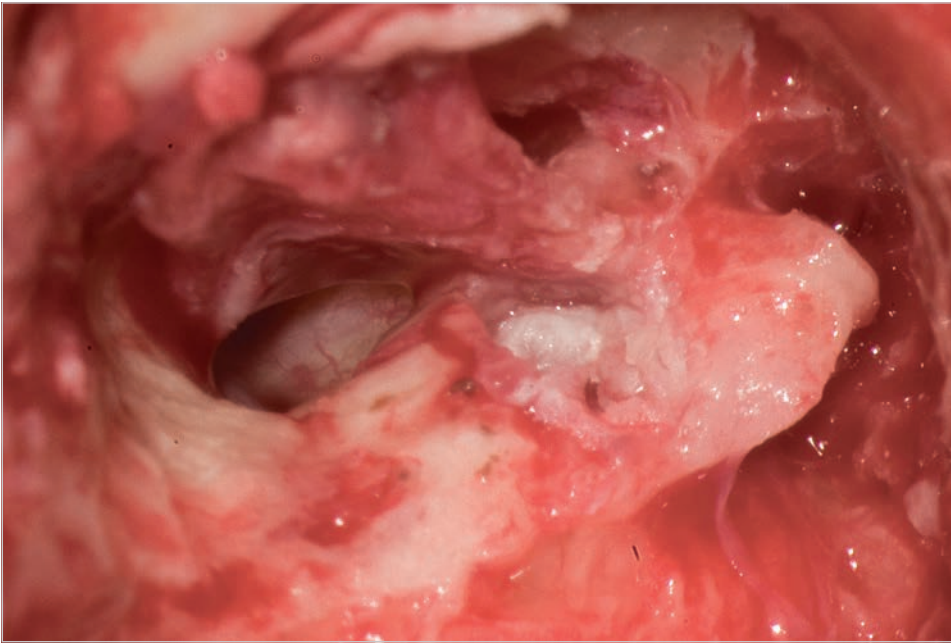


Fig. 7.320 The tympanomeatal flap is elevated to visualize cholesteatoma located around the long process of the incus. The pars tensa of the tympanic membrane is completely preserved.

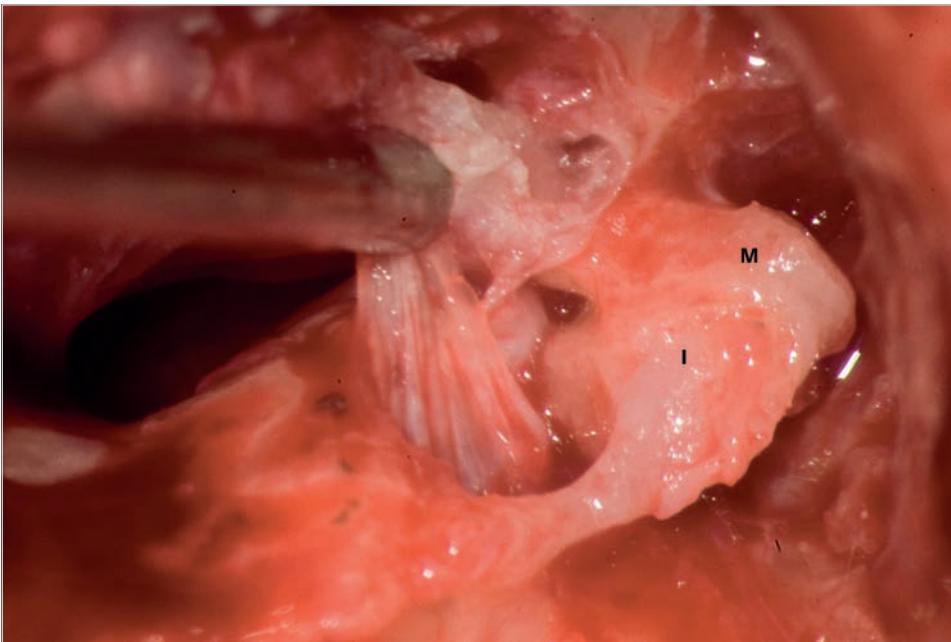


Fig. 7.321 The inferior face of the short process of the incus is eroded by cholesteatoma, but continuity of the ossicular chain is preserved. I, incus; M, malleus.

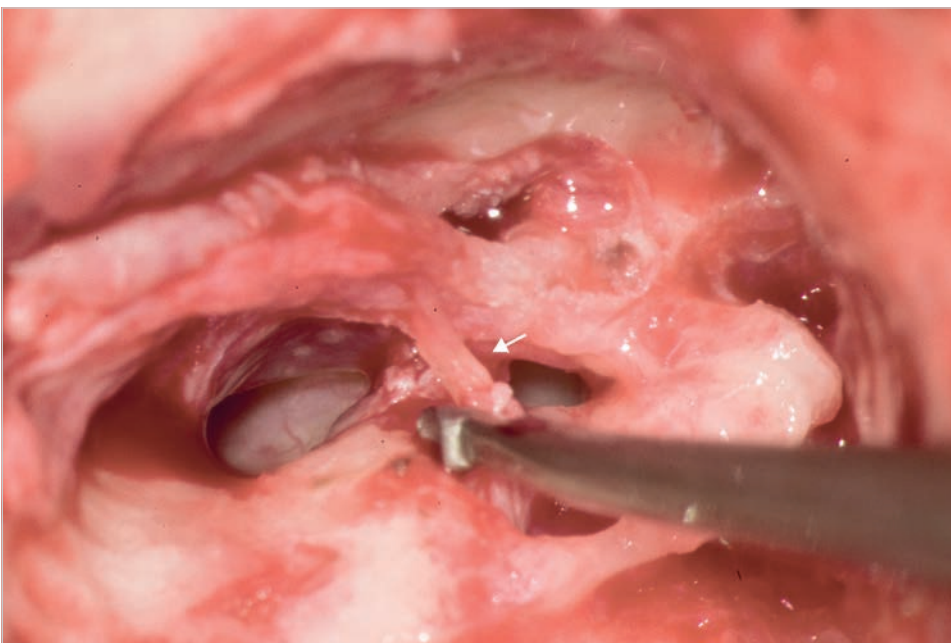


Fig. 7.322 To visualize the posteroinferior face of the matrix, the posterosuperior part of the bony annulus is removed with a curette. Sacrifice of the chorda tympani nerve (arrow) covered with thin matrix enables wide exposure of this area.

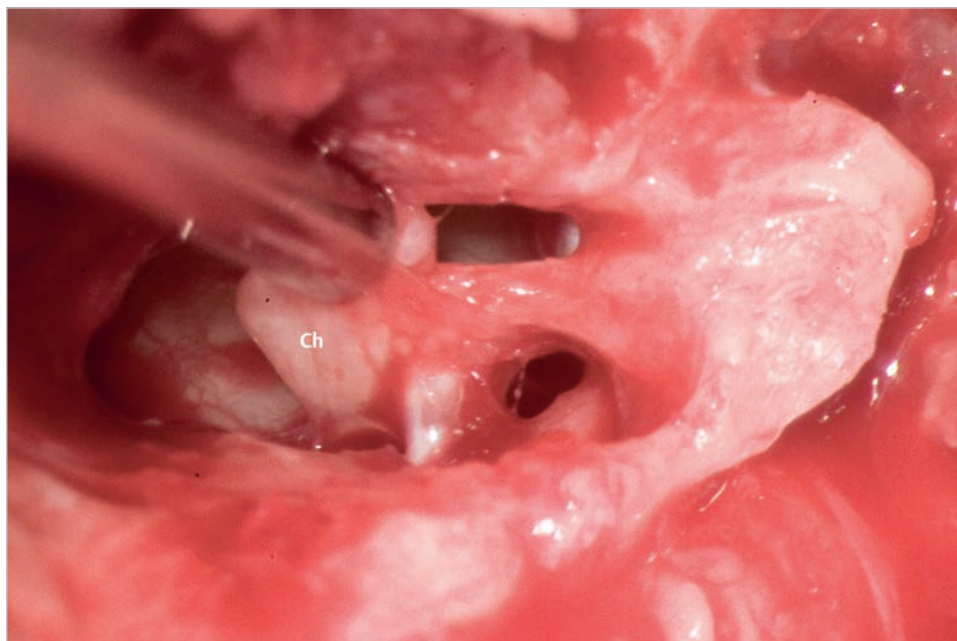


Fig. 7.323 The final piece of cholesteatoma (Ch) adhering to the area of the incudostapedial joint is carefully dissected. Note that lateral faces of the head of the malleus and the body of the incus, and the inferior face of the short process of the incus are eroded.

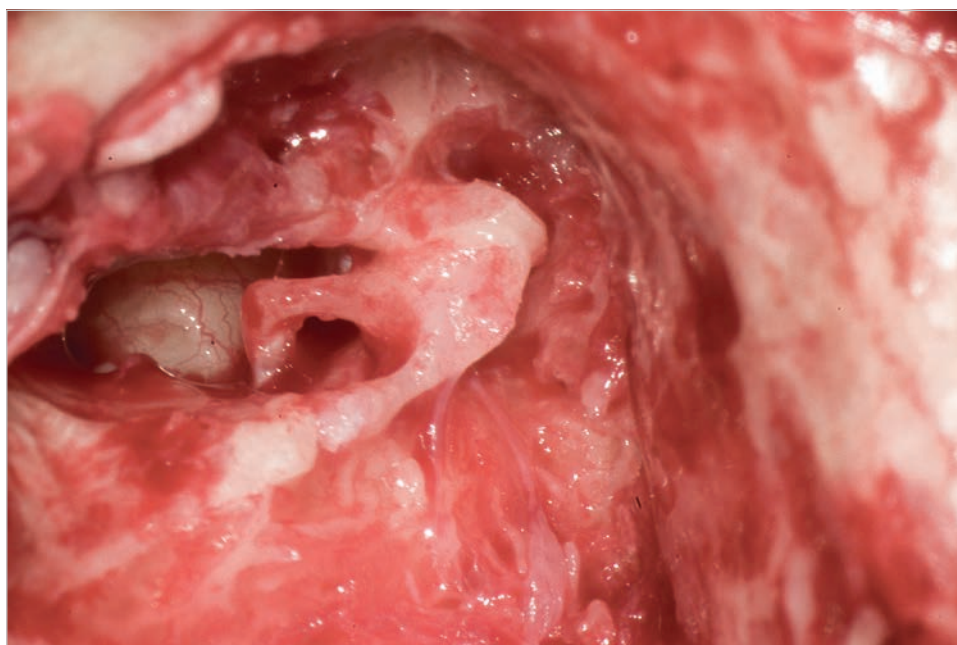


Fig. 7.324 Eradication of cholesteatoma from the middle ear with preservation of the ossicular chain is completed.

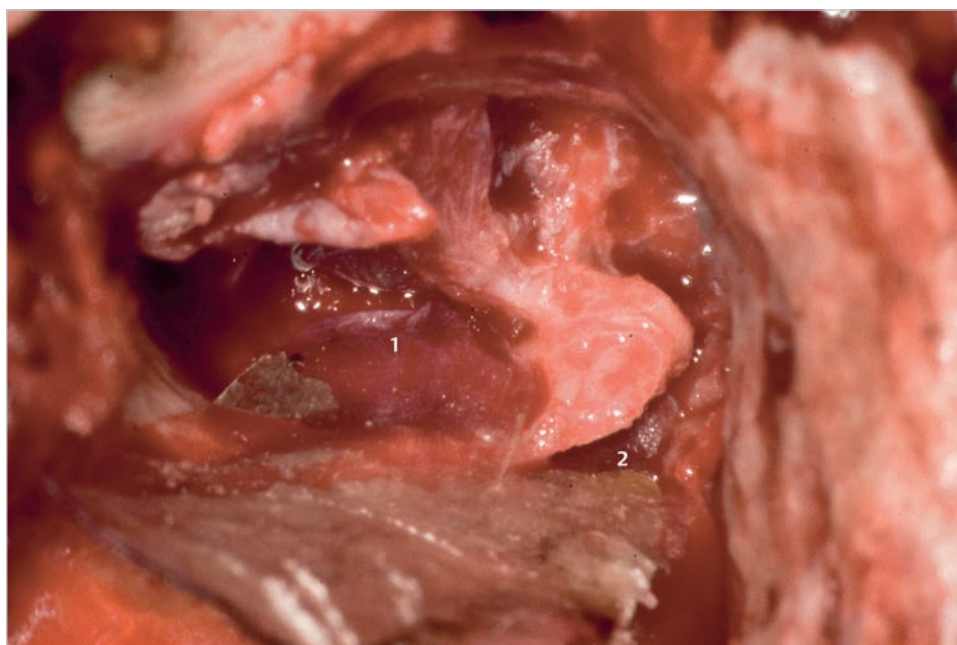


Fig. 7.325 A large piece of temporalis fascia is introduced in the cavity. The body of the incus and the head of the malleus are exteriorized through a cut made in the anterior part of the fascia. One tongue (1) is placed over the long process, and the other tongue (2) is introduced under the ossicular chain. A small piece of cartilage will be placed between the medial wall of the attic and the body of the incus to prevent invagination of the skin postoperatively.

Case 7.22 (Left Ear)

See ► Fig. 7.326, ► Fig. 7.327, ► Fig. 7.328, ► Fig. 7.329, ► Fig. 7.330, ► Fig. 7.331, ► Fig. 7.332, ► Fig. 7.333, ► Fig. 7.334, ► Fig. 7.335.

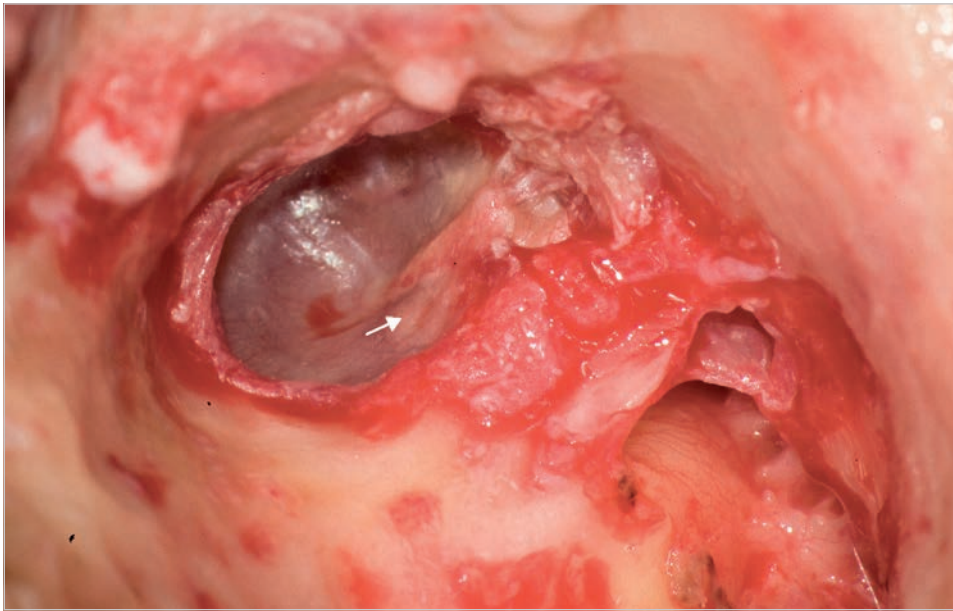


Fig. 7.326 A case of small cholesteatoma limited laterally to the ossicular chain is shown. A canal wall down mastoidectomy has already been accomplished. The whitish area (*arrow*) in the posterosuperior quadrant corresponds to the long process of the incus.

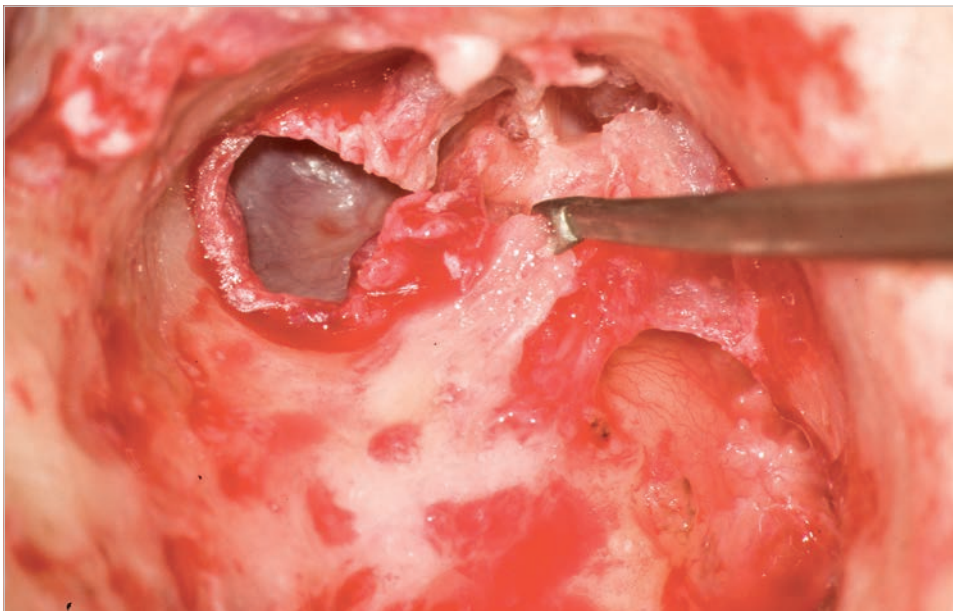


Fig. 7.327 Opening of the matrix visualized a clean dimple located anteriorly to the head of the malleus. The majority of the skin covering the ossicular chain remains healthy. The posterior buttress is removed with a curette taking care not to insult the short process of the incus. The force applied to the curette should not direct to the ossicular chain.

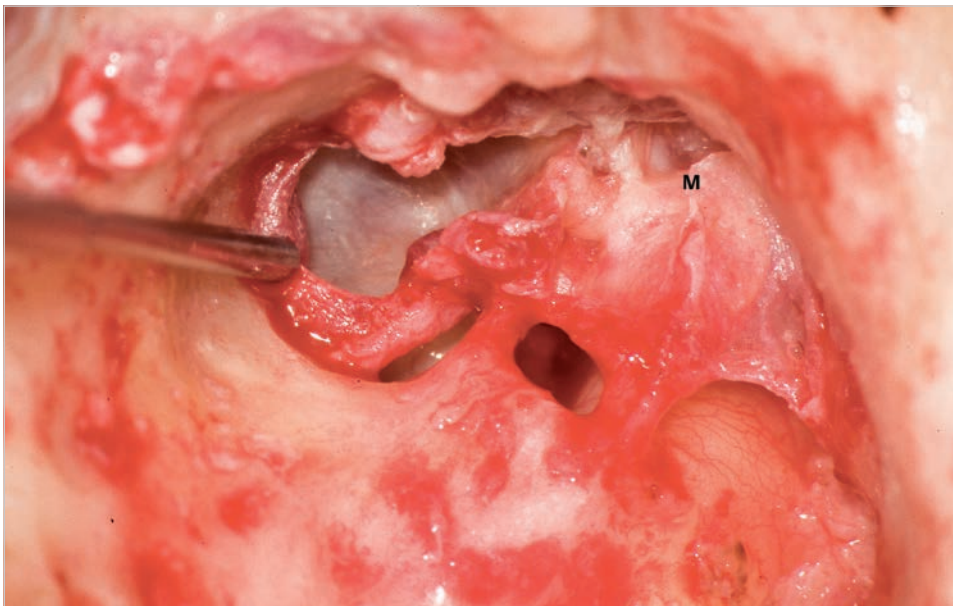


Fig. 7.328 The buttress is removed, and the tympanic cavity is opened posteriorly. M, head of the malleus.

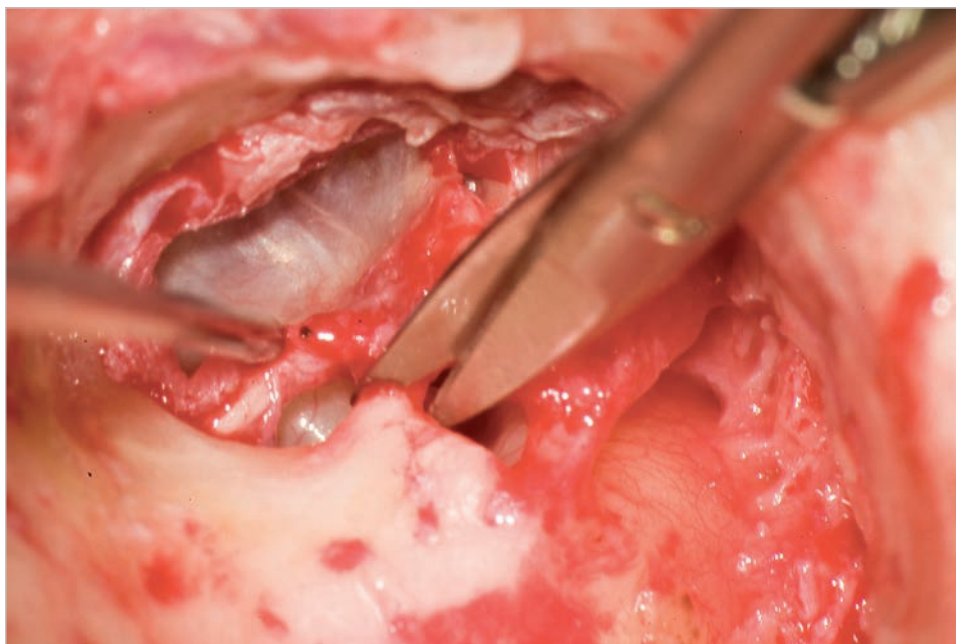


Fig. 7.329 To remove thin matrix descends to the posterior mesotympanum, the chorda tympani nerve is sacrificed.



Fig. 7.330 The bony spur corresponding to the canaliculus chordae is removed with a small diamond burr to further lower the facial ridge.

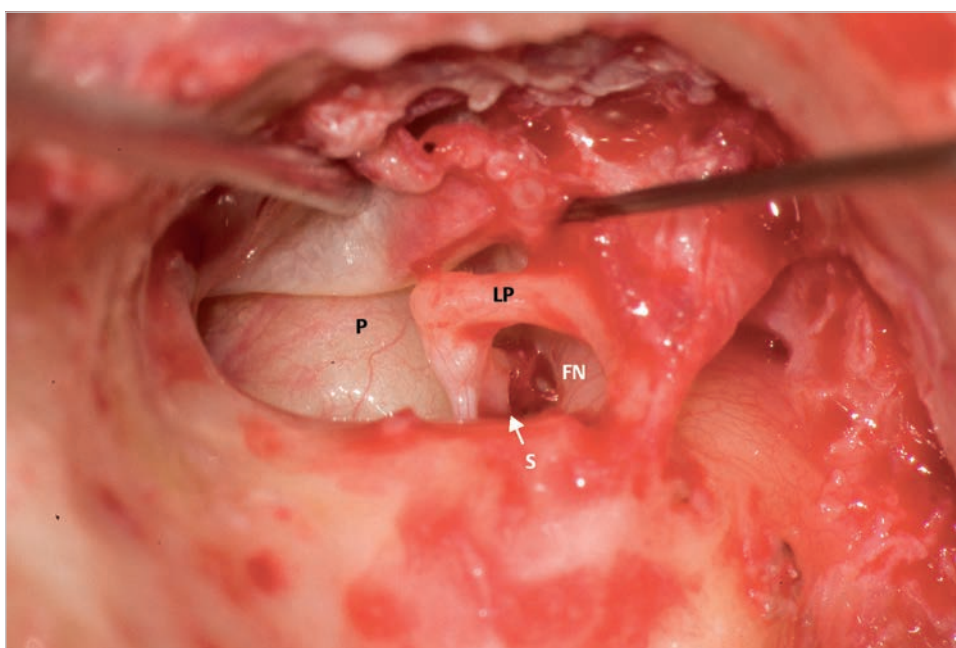


Fig. 7.331 Removal of the bony spur visualized the area of the stapes. The tympanic membrane adherent to the long process of the incus is detached, and the posterior mesotympanum is widely opened. FN, facial nerve; LP, long process of the incus; P, promontory; S, stapes.

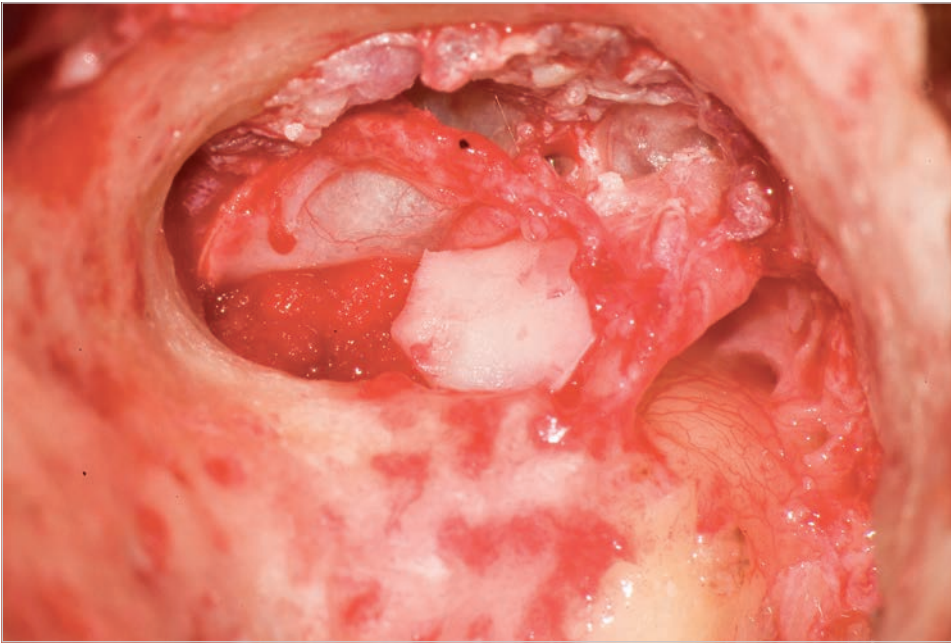


Fig. 7.332 The tympanic cavity is packed with Gelfoam, and a piece of cartilage is placed over the long process of the incus to reinforce the posterosuperior quadrant of the tympanic membrane.

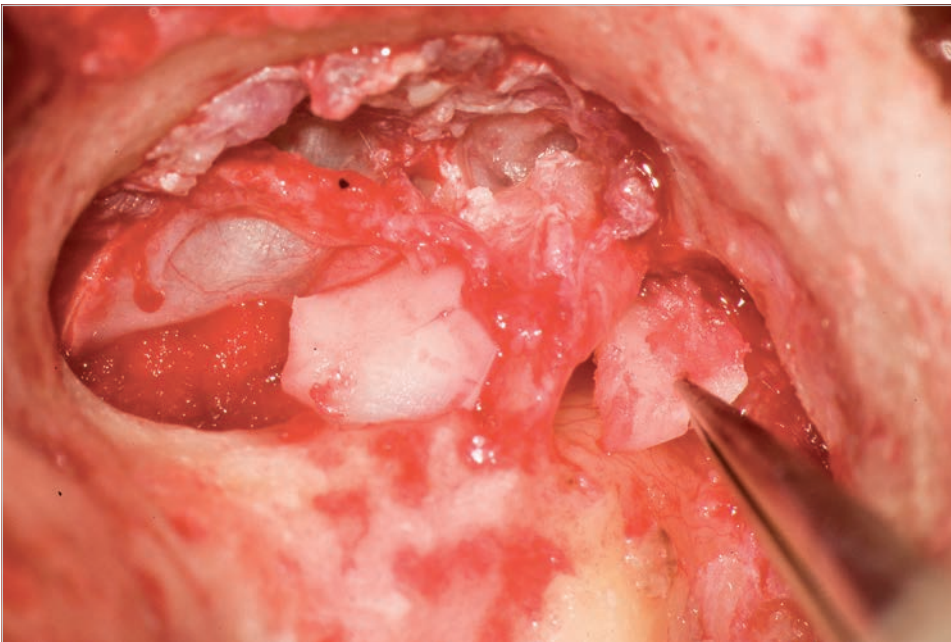


Fig. 7.333 Another small piece of cartilage is placed under the ossicular chain.

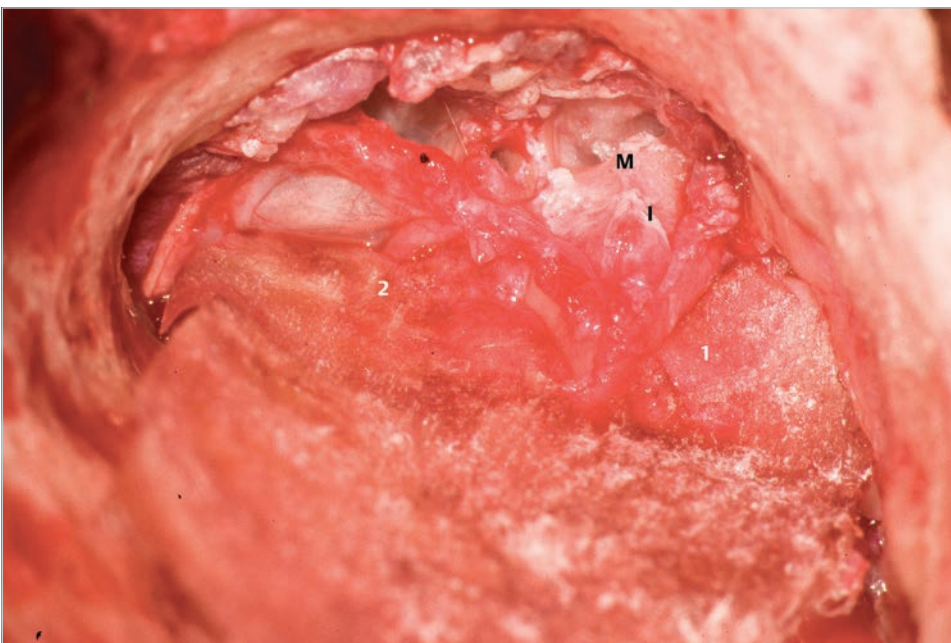


Fig. 7.334 A large piece of fascia with a cut is introduced into the cavity. The superior small part (1) of the fascia is inserted under the body of the incus, and the inferior larger part (2) is placed under the tympanic membrane. The body of the incus is exteriorized through the cut. I, incus; M, malleus.



Fig. 7.335 The final shape of the cavity is shown. The tympanomeatal flap and the cholesteatoma matrix without inflammation are placed back over the fascia.

Case 7.23 (Left Ear)

See ► Fig. 7.336, ► Fig. 7.337, ► Fig. 7.338, ► Fig. 7.339, ► Fig. 7.340, ► Fig. 7.341, ► Fig. 7.342.



Fig. 7.336 Cholesteatoma is eradicated and the cavity is ready for reconstruction. The ossicular chain is preserved even though some erosion is seen in the body of the incus.



Fig. 7.337 Middle fossa dura is exposed in the tegmen of the mastoid.



Fig. 7.338 In some cases of cholesteatoma, matrix covering the dura may be difficult to dissect in one piece especially at the order of the bone. In such cases, the dura of suspicious area is coagulated with bipolar to reduce possibility of residual. Use of a monopolar is prohibited to avoid perforation and subsequent liquorrhea.



Fig. 7.339 The coagulated dura is covered with a piece of cartilage.



Fig. 7.340 Pieces of cartilage (*arrows*) are used to obliterate the space behind the ossicular chain.



Fig. 7.341 Bone paste is applied to cover the cartilage over the dura and to obliterate partially the mastoid.

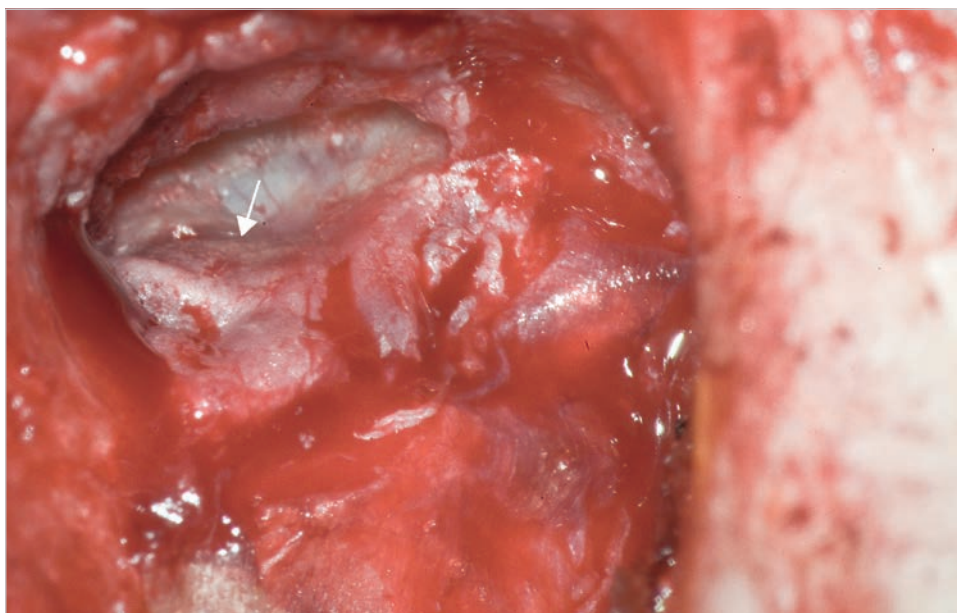


Fig. 7.342 The posterosuperior quadrant of the tympanic membrane is reinforced with a piece of cartilage (*arrow*). Cavity will be covered with a large piece of fascia grafted underlay. The tympanomeatal flap is replaced over the fascia.

Case 7.24 (Left Ear)

See ► Fig. 7.343, ► Fig. 7.344, ► Fig. 7.345, ► Fig. 7.346, ► Fig. 7.347, ► Fig. 7.348, ► Fig. 7.349, ► Fig. 7.350, ► Fig. 7.351, ► Fig. 7.352.



Fig. 7.343 Canal wall mastoidectomy is carried out. Cholesteatoma (Ch) filling the attic is seen.

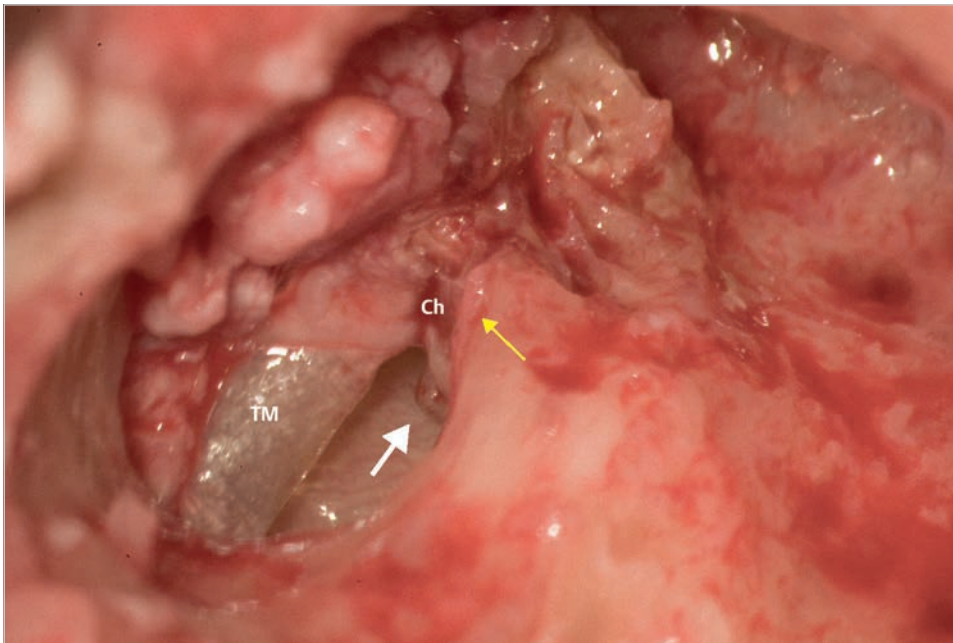


Fig. 7.344 The majority of the cholesteatoma is removed from the attic and the antrum except the area around the ossicular chain. The tympanomeatal flap is reflected anteriorly to expose the matrix descending into the tympanic cavity behind the chorda tympani nerve (*yellow arrow*) to reach the incudostapedial joint (*white arrow*). Ch, cholesteatoma; TM, tympanic membrane.

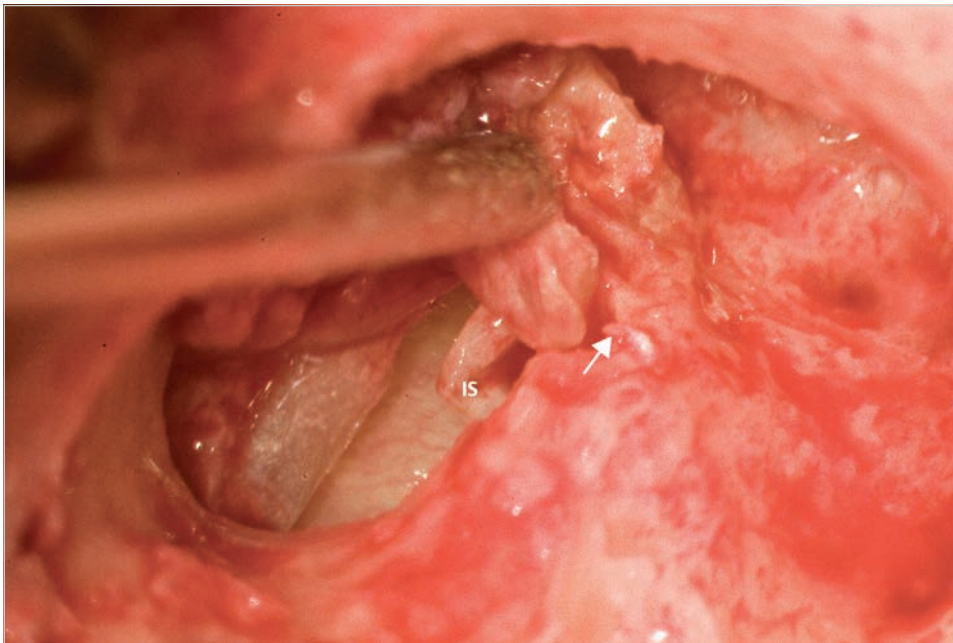


Fig. 7.345 The chorda tympani nerve is sacrificed, and the inferior pole of cholesteatoma is gently pushed up to detach the matrix covering the long process of the incus. The short process of the incus is identified (*arrow*). IS, incudostapedial joint.

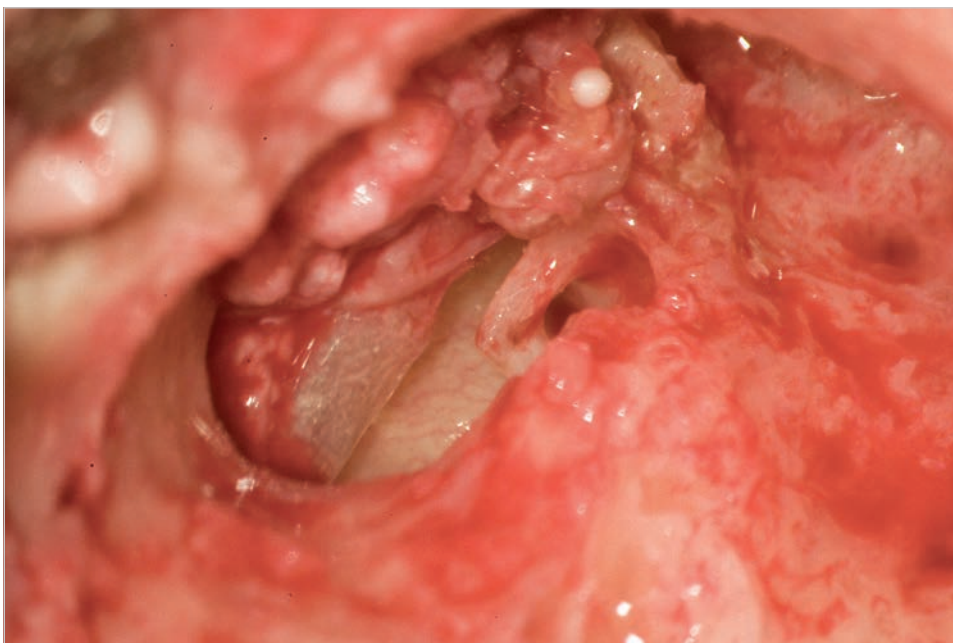


Fig. 7.346 Removal of cholesteatoma in the mesotympanum is completed. The long process of the incus and the stapes are connected.



Fig. 7.347 The matrix invaginating into the supratubal recess anteriorly to the head of the malleus is shown. Ch, cholesteatoma.



Fig. 7.348 The matrix is removed from the supratubal recess. Cholesteatoma between the ossicular chain and the medial wall of the attic is then removed with meticulous care. Ch, cholesteatoma.

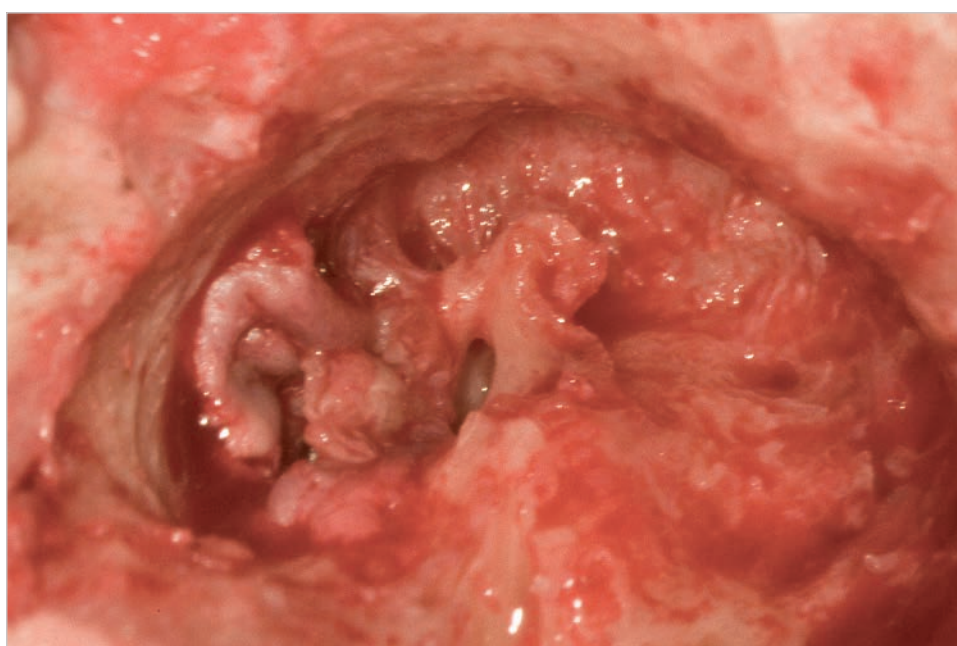


Fig. 7.349 The cholesteatoma is eradicated from the middle ear.

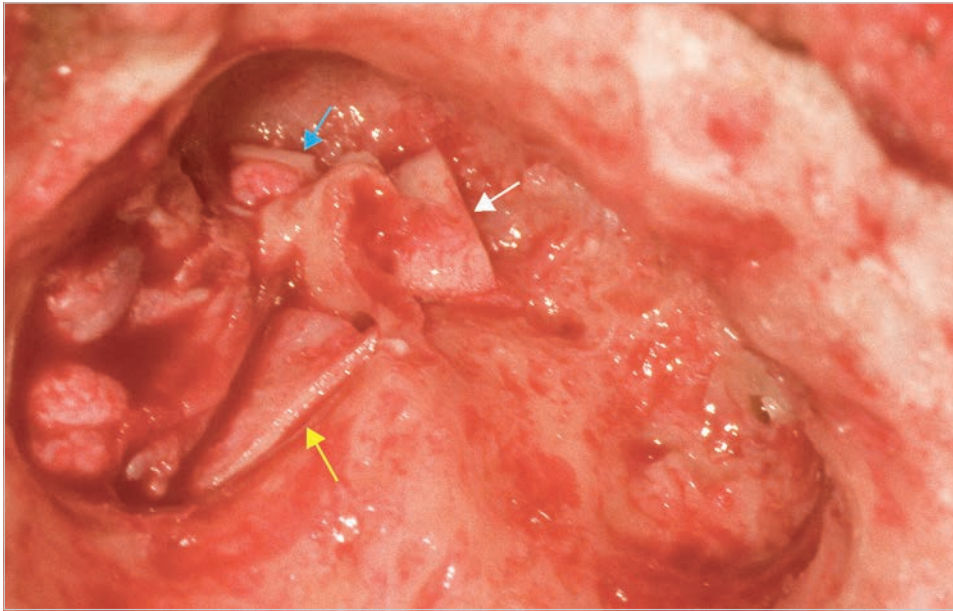


Fig. 7.350 Pieces of cartilage are used to reinforce the posterosuperior quadrant (*yellow arrow*), and to obliterate the space medial to the ossicular chain (*white arrow*) and the supratubal recess (*blue arrow*) to impede postoperative reformation of cholesteatoma.

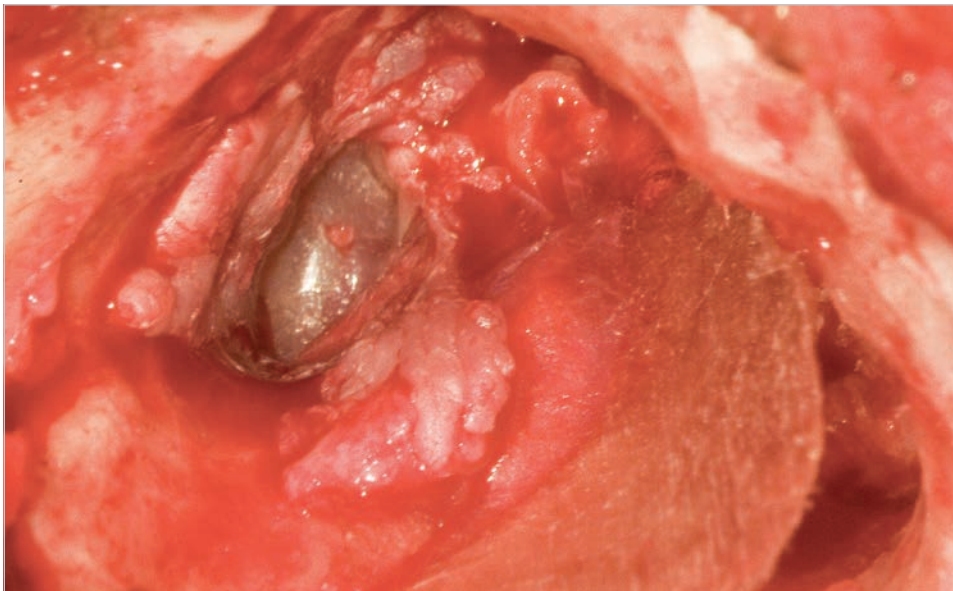


Fig. 7.351 The supratubal recess is further obliterated with cartilage, and a large piece of temporalis fascia with a cut anteriorly is grafted. The tympanomeatal flap is replaced over the fascia. Exteriorization of the ossicular chain ensures exteriorization of possible residual covering the erosion.



Fig. 7.352 The otoscopy of a representative case during follow-up 3 months after modified Bondy technique in the right ear. Note the well-epithelized dry cavity.

7.2.2 Extended Modified Bondy Technique

Because the modified Bondy technique leaves the ossicular chain intact, the best indication of this technique is cholesteatoma that only reaches the area visible under the microscope after bone work. Medial and anteromedial extension eventually make invisible portion, increasing risk of residual disease on medial face of the chain and/or walls of the attic where drilling is not practical. However, in limited cases, the medial compartment can be dissected in one layer, making preservation of the chain possible. Such possibility depends on extension of cholesteatoma, thickness of the matrix, adhesion to bony structures. Sufficient bone removal to maximize access

to cholesteatoma followed by adequate debulking and evacuation of debris improve visibility, and movability of the matrix is of tremendous importance in such dissection. Decision to preserve the ossicular chain is based not on radiology, but on intraoperative findings.

When eradication of cholesteatoma is suspicious, removal of the incus, and the head of the malleus if required, is indicated. The mucosa covering the mesotympanum often stays healthy in such cases, and one stage surgery may be possible.

Case 7.25 (Right Ear)

See ► Fig. 7.353, ► Fig. 7.354, ► Fig. 7.355, ► Fig. 7.356, ► Fig. 7.357, ► Fig. 7.358, ► Fig. 7.359, ► Fig. 7.360.

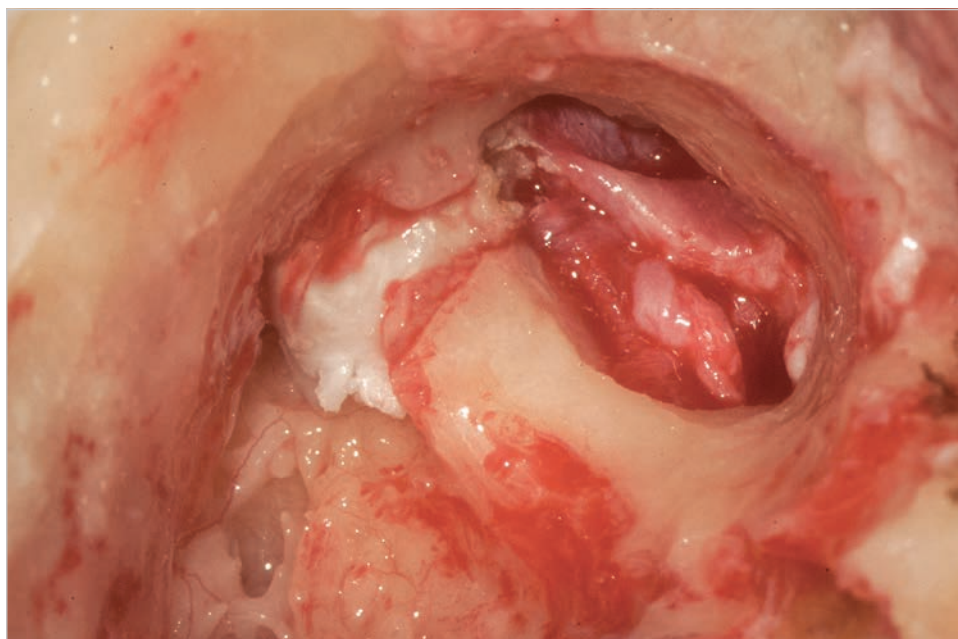


Fig. 7.353 The posterior wall is drilled to reach the area of cholesteatoma filling the attic. Care should be taken in this procedure not to touch the functioning ossicular chain. The distance between the short process and the lateral wall of the fossa incudis may be very small. Removal of the lateral wall can be safely performed with a curette.

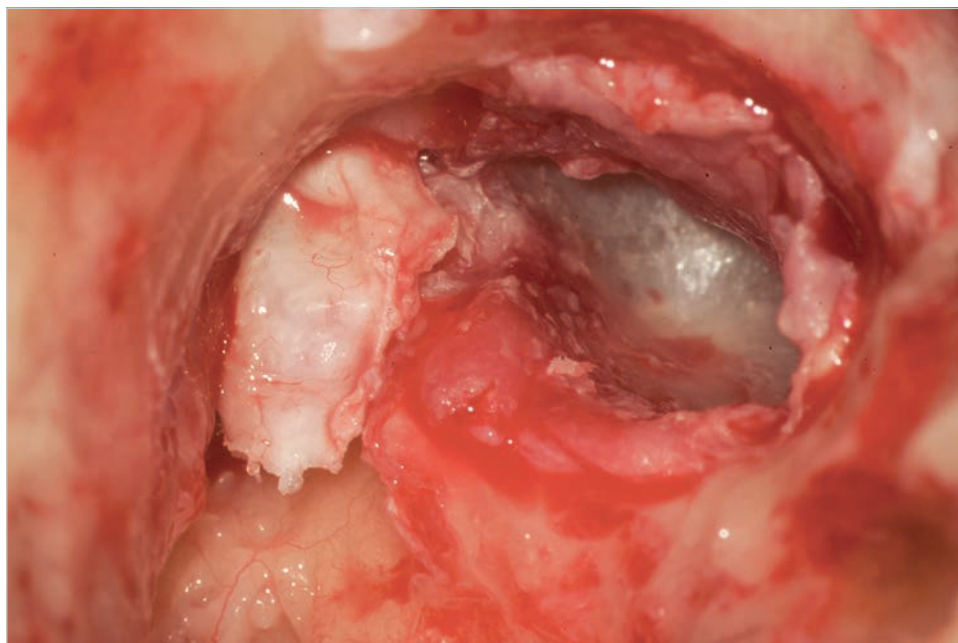


Fig. 7.354 Debris filling the cholesteatoma is evacuated, and dissection of the matrix is started from the superior wall of the attic. Ch, cholesteatoma.

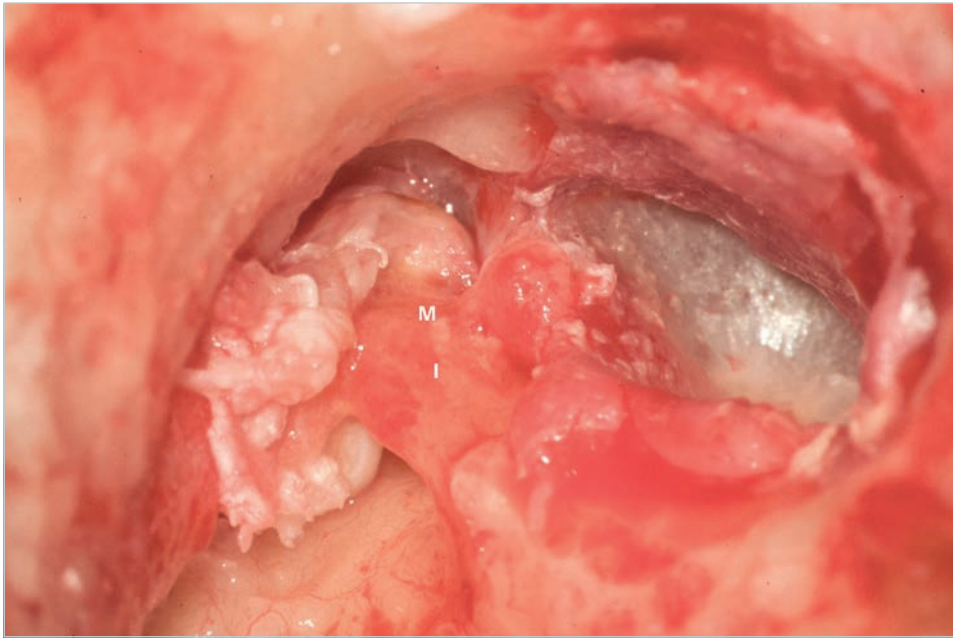


Fig. 7.355 Access to the attic is enlarged taking care not to insult the ossicular chain. Dissection is proceeded anteriorly to reach the supratubal recess. Evacuation of debris plays key role to create space for dissection from bony walls. Note that a view of the medial end of this portion is blocked by the ossicular chain. I, incus; M, malleus.

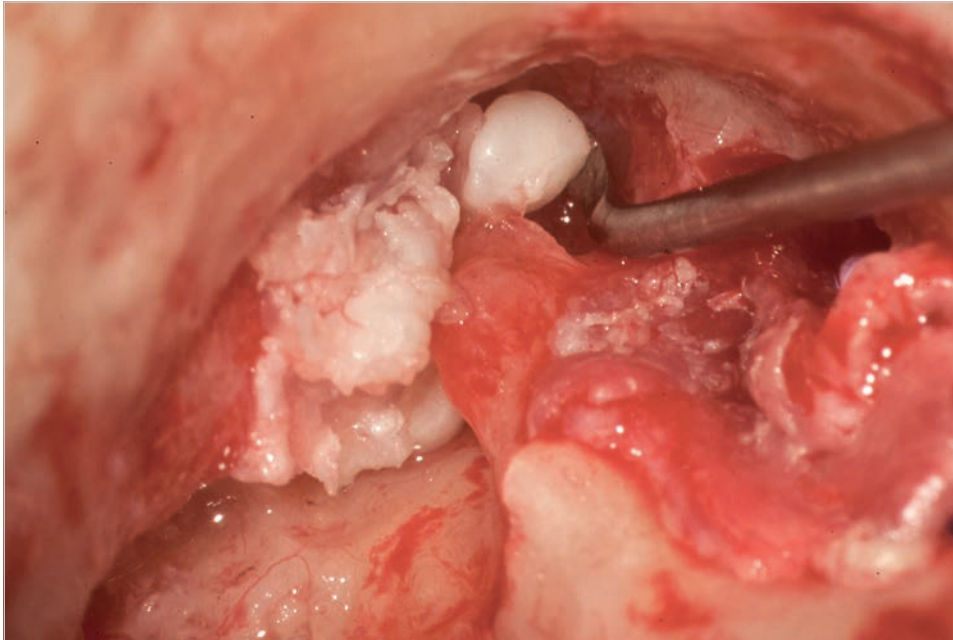


Fig. 7.356 The matrix is pushed superiorly with the raspatory taking care not to disrupt it.

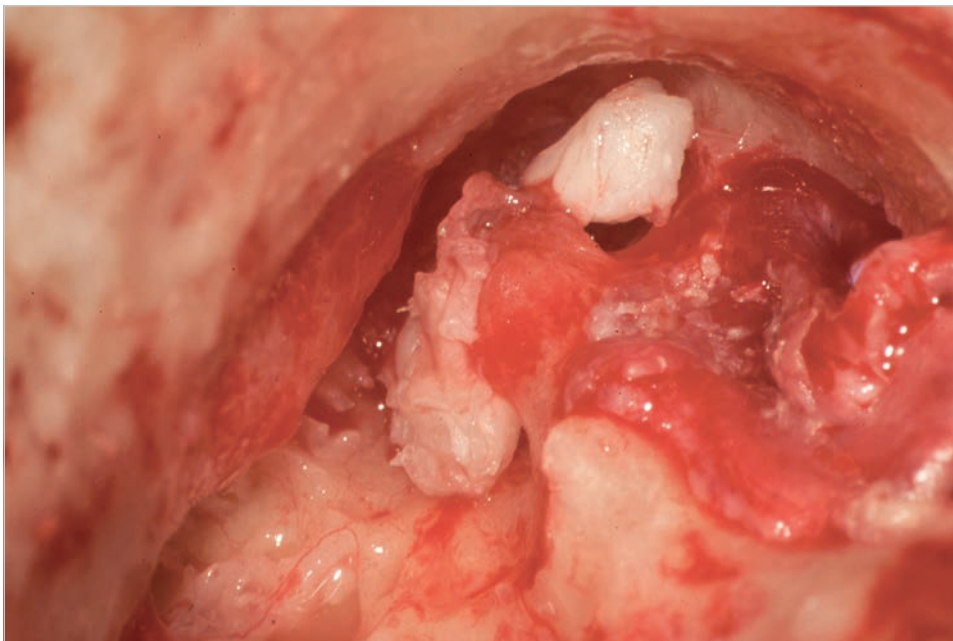


Fig. 7.357 Debulking of the cholesteatoma between the tegmen and the chain makes some room for further dissection from the medial face of the ossicular chain. Only when the one-piece removal of the matrix follows, the chain can be preserved.

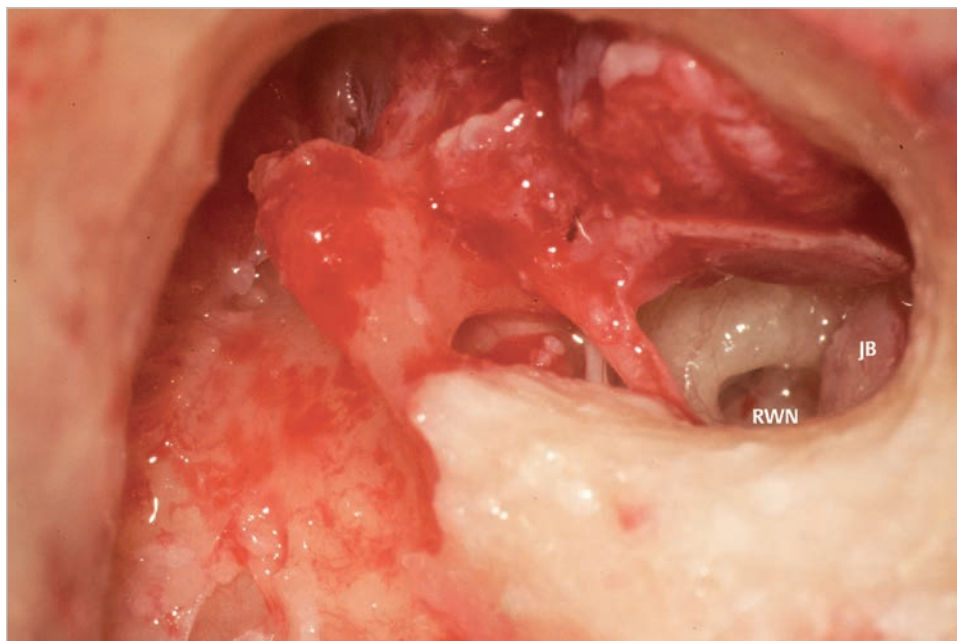


Fig. 7.358 Eradication of cholesteatoma is accomplished. The tympanomeatal flap is elevated to verify absence of cholesteatoma in the tympanic cavity and continuity of the ossicular chain. The chorda tympani nerve (*arrow*) is preserved in this case. A jugular bulb is seen inferiorly to the round window niche. JB, jugular bulb; RWN, round window niche.

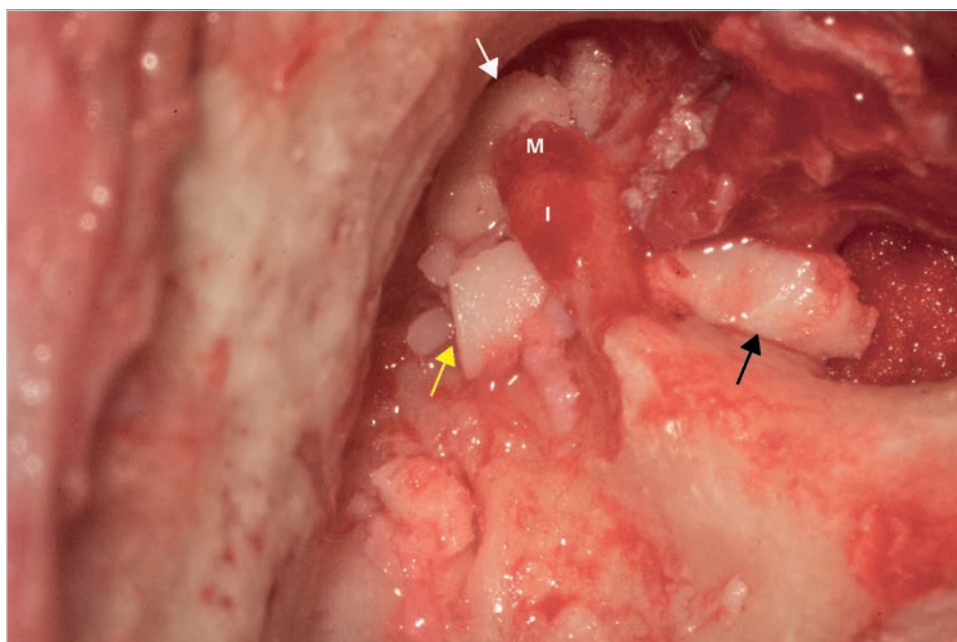


Fig. 7.359 Pieces of cartilage are used to obliterate the supratubal recess (*white arrow*), the space under the ossicular chain (*yellow arrow*), and to reinforce the posterosuperior quadrant of the tympanic membrane (*black arrow*). I, incus; M, malleus.



Fig. 7.360 A large piece of fascia is used to close the tympanic cavity and to cover the medial wall of the mastoid. The ossicular chain is exteriorized through a cut made in the fascia.

Case 7.26 (Right Ear)

See ► Fig. 7.361, ► Fig. 7.362, ► Fig. 7.363, ► Fig. 7.364, ► Fig. 7.365,
► Fig. 7.366, ► Fig. 7.367, ► Fig. 7.368.

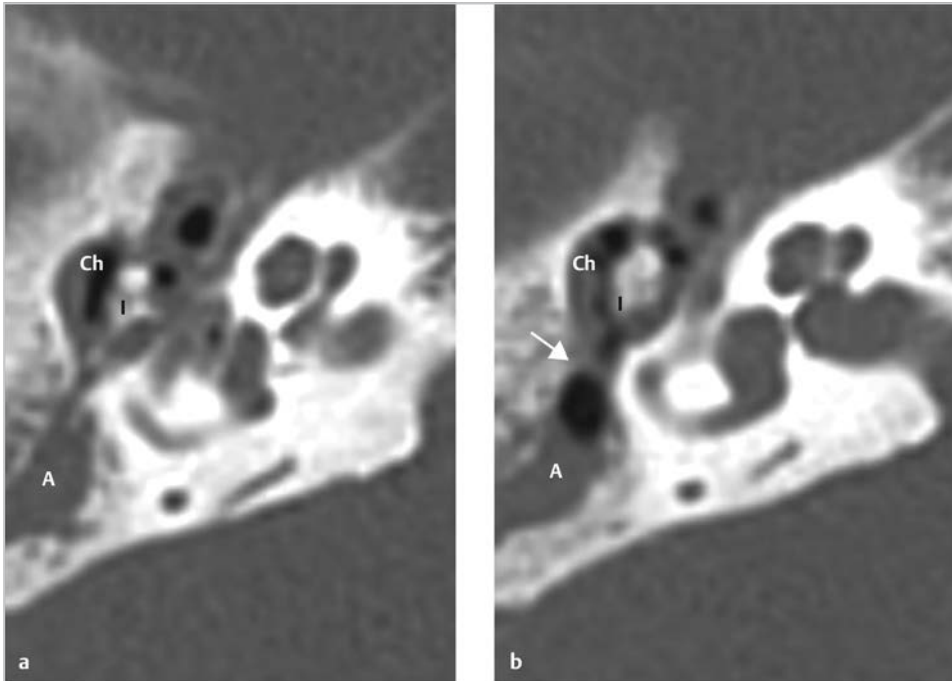


Fig. 7.361 A case of cholesteatoma to which extended indication of modified Bondy technique is applied is shown. **(a)** The axial CT showed presence of cholesteatoma (Ch) in the attic with nearly intact ossicular chain. The posterior limit of the cholesteatoma seems to be located at the level of the aditus ad antrum (*arrow*), and **(b)** the antrum seems to be ventilated to some extent. Soft tissue density medially to the intact ossicular chain is indistinguishable from middle ear effusion. A, antrum; I, incus.

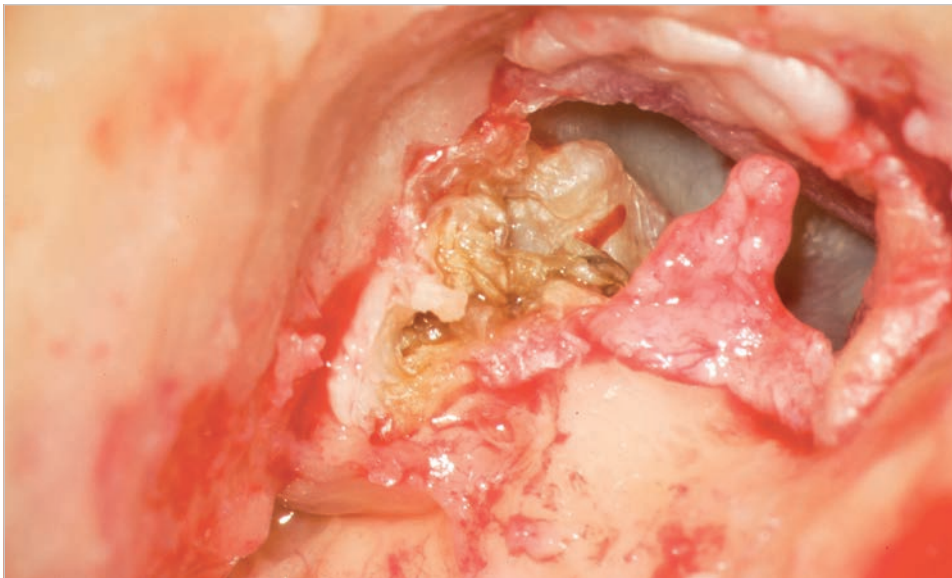


Fig. 7.362 A canal wall down mastoidectomy is carried out. The cholesteatoma filled with debris reached the aditus ad antrum is seen.



Fig. 7.363 Access to the cholesteatoma is enlarged, and the matrix is reduced. The tympanic cavity is opened posteriorly. The superior end of the cholesteatoma invaginated from the posterosuperior quadrant of the tympanic membrane is seen under the body of the incus (*arrow*). Sufficient removal of the bone laterally to the lateral semicircular canal (*blue arrow*) plays key role to manage cholesteatoma in this location. No pathology is seen inferiorly to the quadrant. I, incus; LSC, lateral semicircular canal.

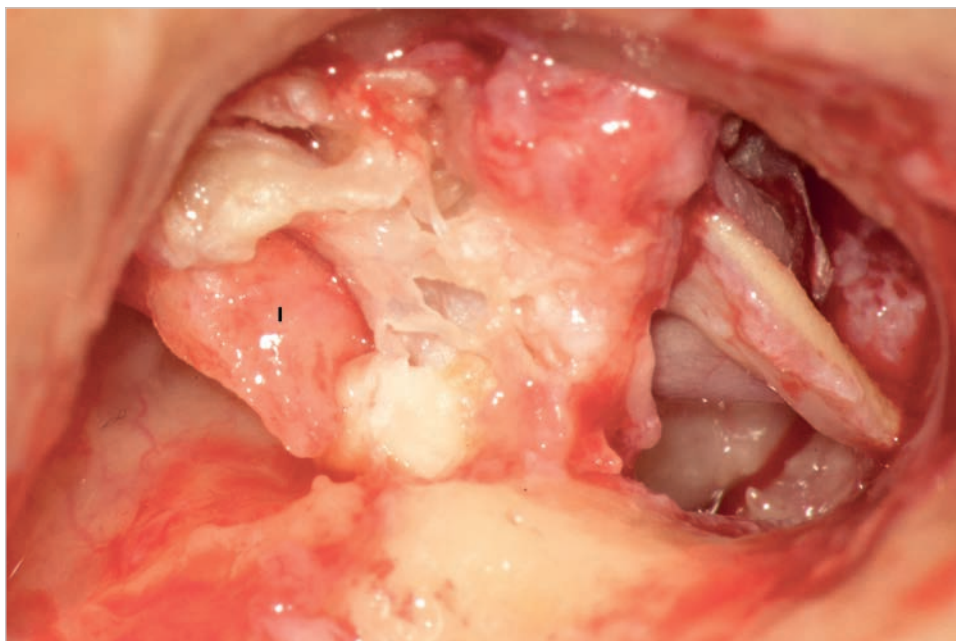


Fig. 7.364 The posterior mesotympanum is opened by lowering the facial ridge. The cholesteatoma goes under the body of the incus through the tract between the posterior wall and the long process of the incus. The matrix is started to be dissected from the incus with great care. I, incus.

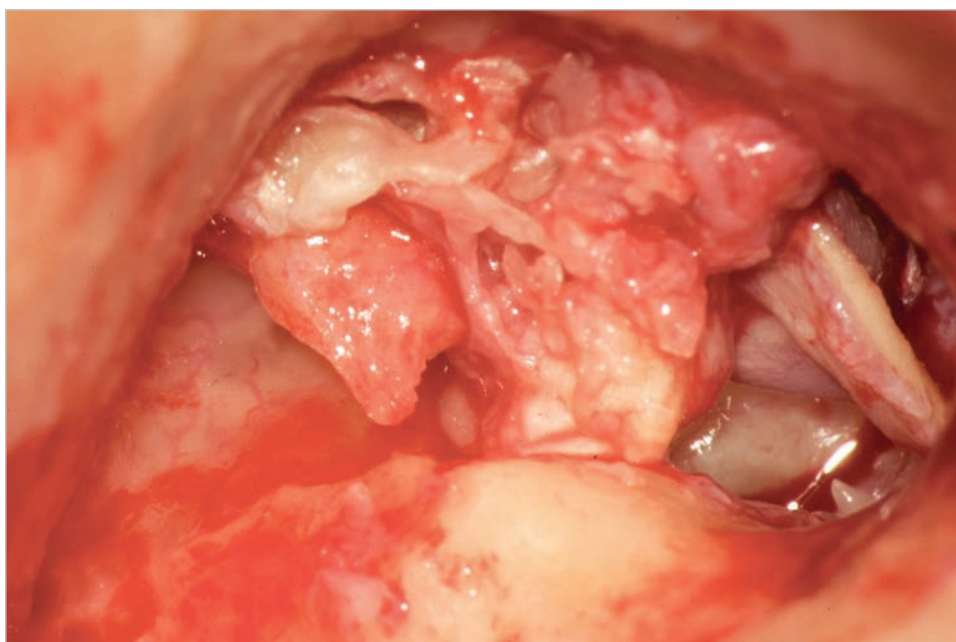


Fig. 7.365 Debris is partially evacuated to facilitate dissection under the ossicular chain. I, incus.

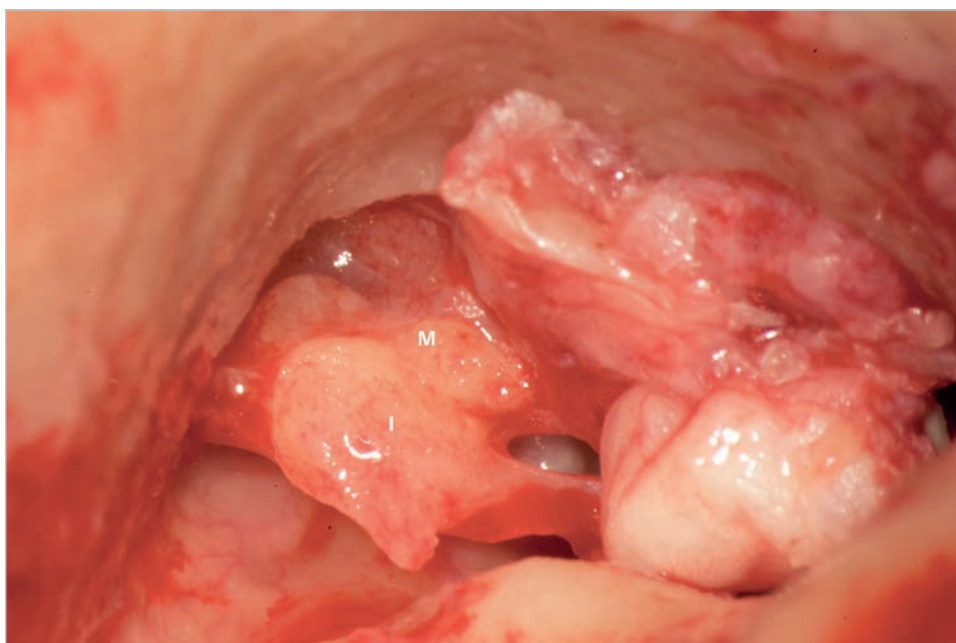


Fig. 7.366 The matrix is removed from the middle ear structures without disruption. Preservation of the ossicular chain is indicated. M, malleus.

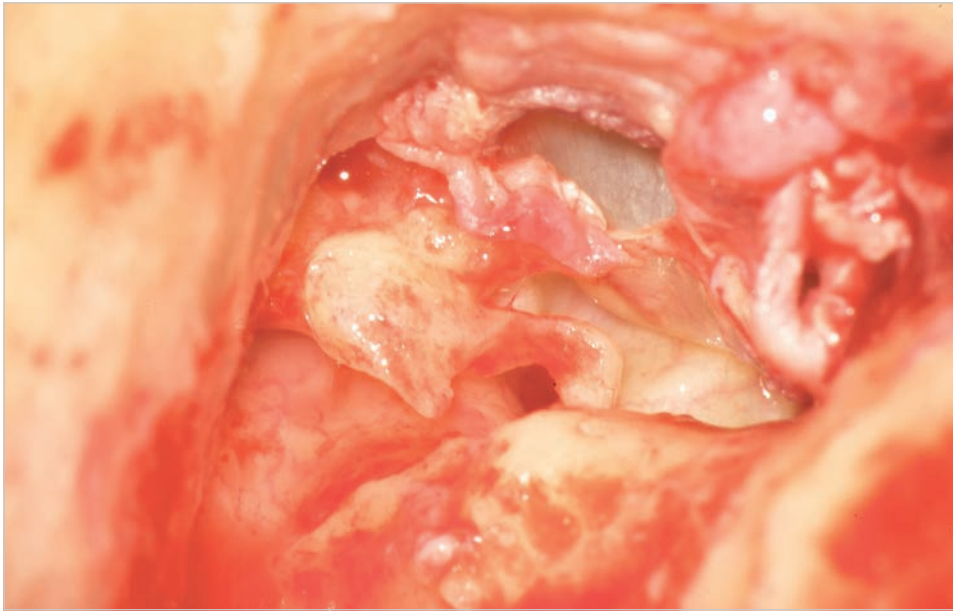


Fig. 7.367 The middle ear is free of cholesteatoma. The preserved ossicular chain is shown.

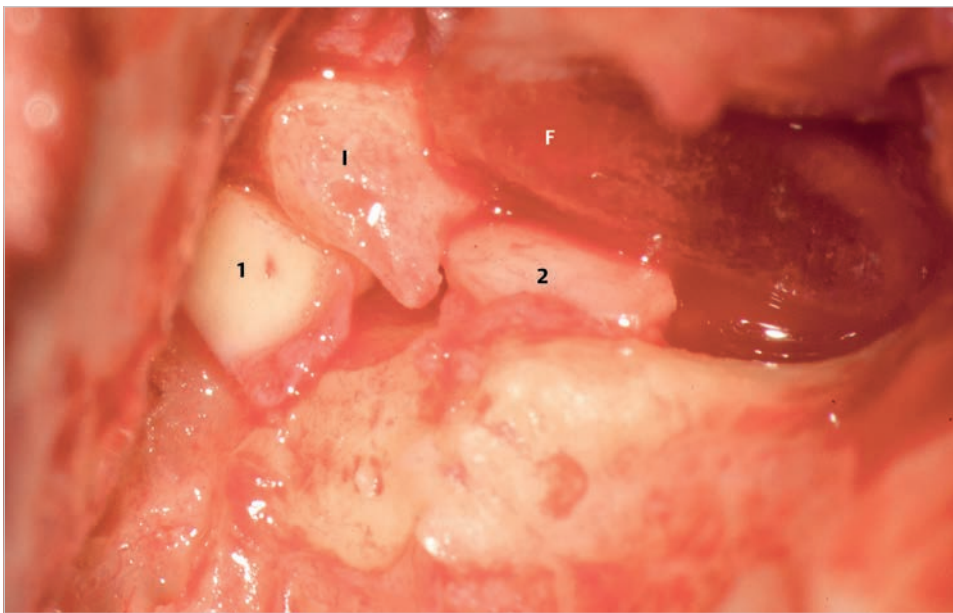


Fig. 7.368 After packing the tympanic cavity with Gelfoam, a large piece of fascia is grafted underlay, and reflected anteriorly. Two pieces of cartilage are used to avoid postoperative retraction. One is placed under the body of the incus (1), and the other thin piece is placed in the posterosuperior quadrant (2). The cavity will be covered with a large piece of fascia grafted underlay. F, fascia; I, incus.

Case 7.27 (Left Ear)

See ► Fig. 7.369, ► Fig. 7.370, ► Fig. 7.371, ► Fig. 7.372, ► Fig. 7.373, ► Fig. 7.374, ► Fig. 7.375, ► Fig. 7.376, ► Fig. 7.377, ► Fig. 7.378, ► Fig. 7.379.

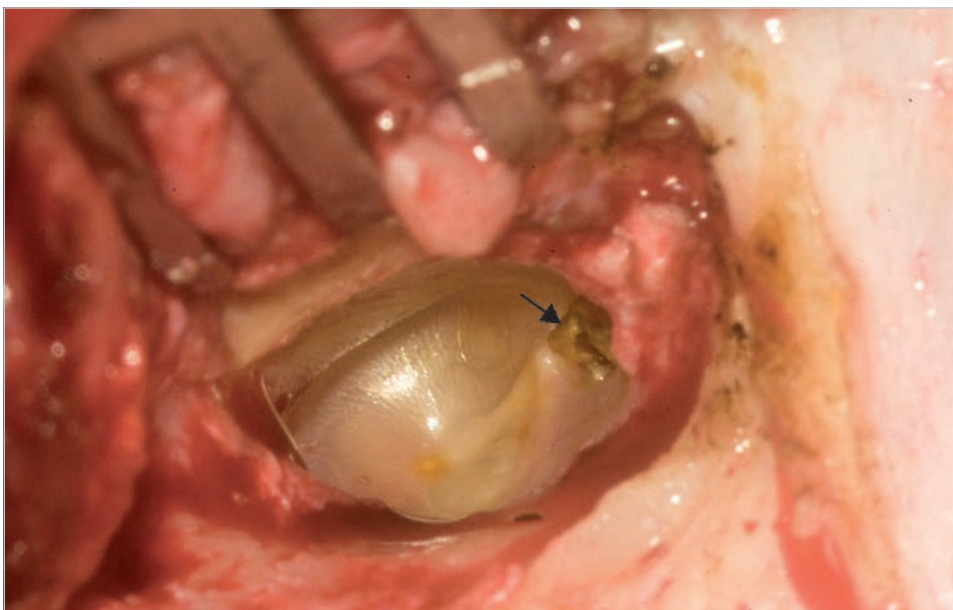


Fig. 7.369 Through retroauricular incision, the meatus is opened and the tympanic membrane is visualized. A small erosion with debris is seen in the pars flaccida of the tympanic membrane. The pars tensa keeps normal shape. A white mass corresponds to the cholesteatoma touches the posterosuperior quadrant (arrow).



Fig. 7.370 Mastoidectomy is carried out, and debulking of the cholesteatoma filling the antrum is on the way.

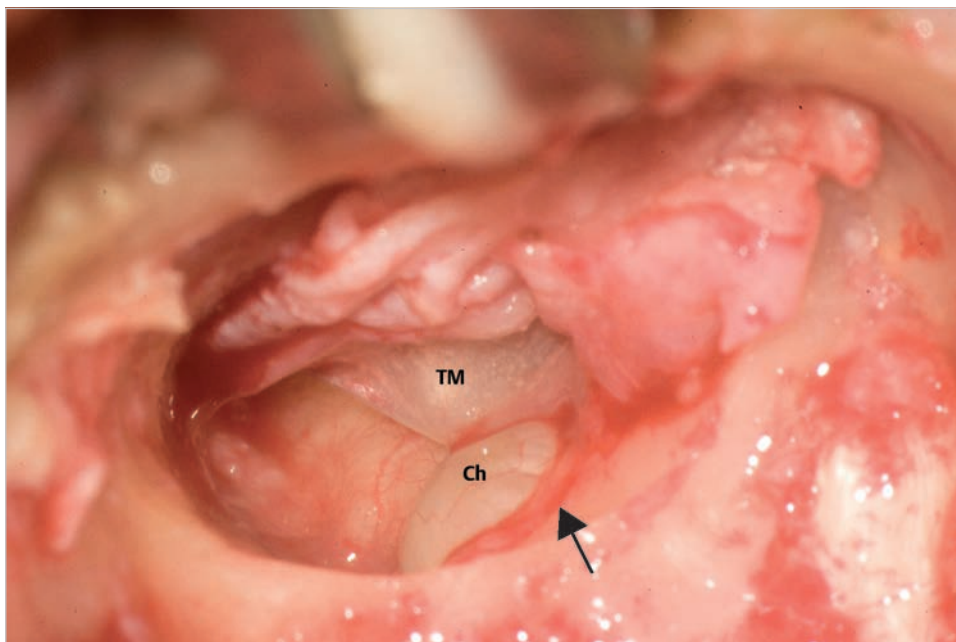


Fig. 7.371 The tympanic cavity is opened from inferoposterior, and the tympanomeatal flap is reflected anteriorly. Cholesteatoma passing under the chorda tympani nerve (*arrow*) to occupy the posterosuperior part of the tympanic cavity is shown. Ch, cholesteatoma; TM, tympanic membrane.

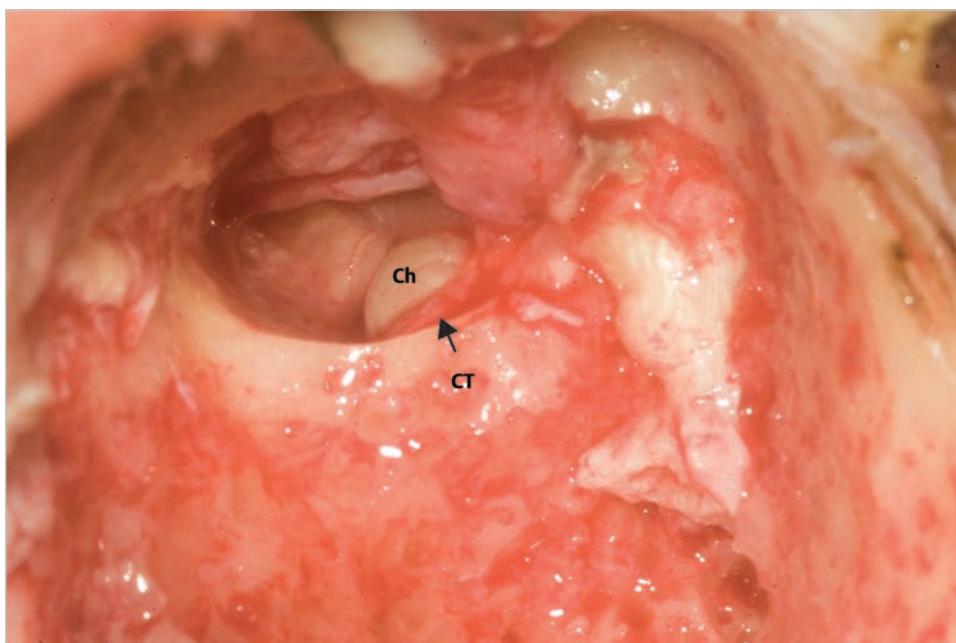


Fig. 7.372 The facial bridge is removed to open the attic. Since the ossicular chain is preserved, care should be taken not to touch the short process of the incus with burrs. Removal of the final bone covering the fossa incudes with a curette is safer choice. Ch, cholesteatoma; CT, chorda tympani.

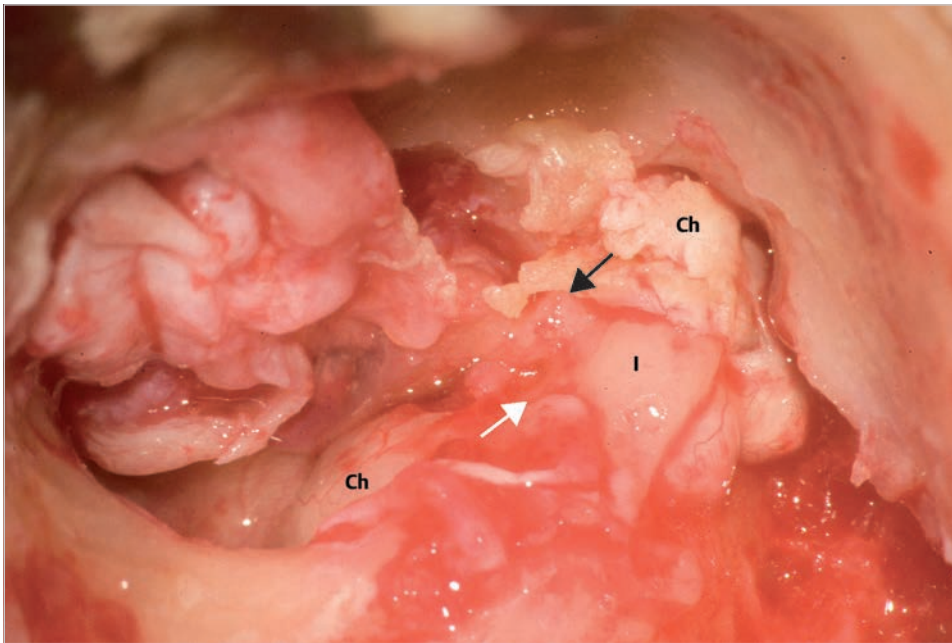


Fig. 7.373 The chorda tympani nerve is sacrificed and the facial ridge is lowered. The lateral face of the incus and the handle of the malleus are exposed. The lateral process of the malleus is indicated by the black arrow. Note that erosion of the incus is limited, and the cholesteatoma descending to the posterior mesotympanum passes between the long process of the incus (*white arrow*) and the posterior wall of the tympanic cavity. Ch, cholesteatoma; I, incus.

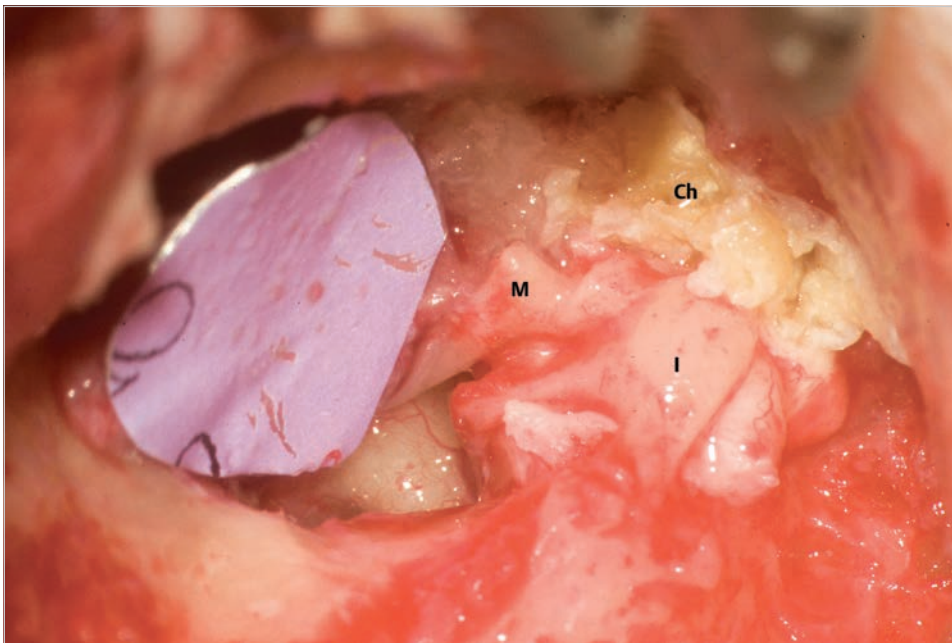


Fig. 7.374 The anterosuperior part of the bony annulus is drilled after detaching the fibrous annulus to open the supratubal recess filled with cholesteatoma. Care must be taken during drilling not to touch the lateral process and the head of the malleus. The tympanomeatal flap should be protected with an aluminum sheeting. The location of the cholesteatoma, medially and anteriorly to the ossicular chain, is usually an indication of removal of the chain. Ch, cholesteatoma; I, incus; M, malleus.

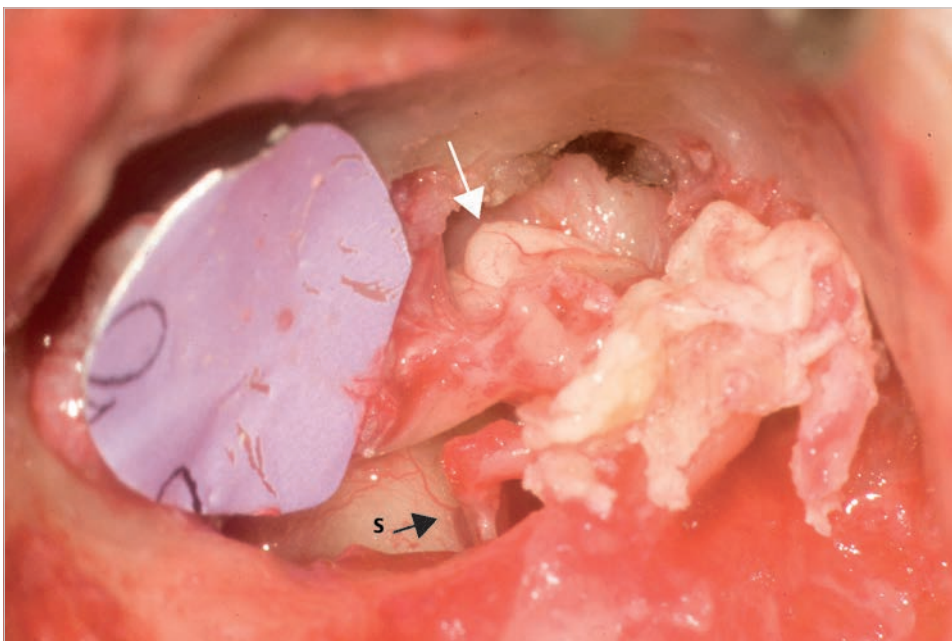


Fig. 7.375 In this particular case, since the matrix is not so adherent to bony structures, removal of cholesteatoma is attempted with leaving intact ossicular chain. The matrix is dissected from the superior face of the stapes, and its anterior end reaching the area of the eustachian tube is visualized (*white arrow*). S, stapes.

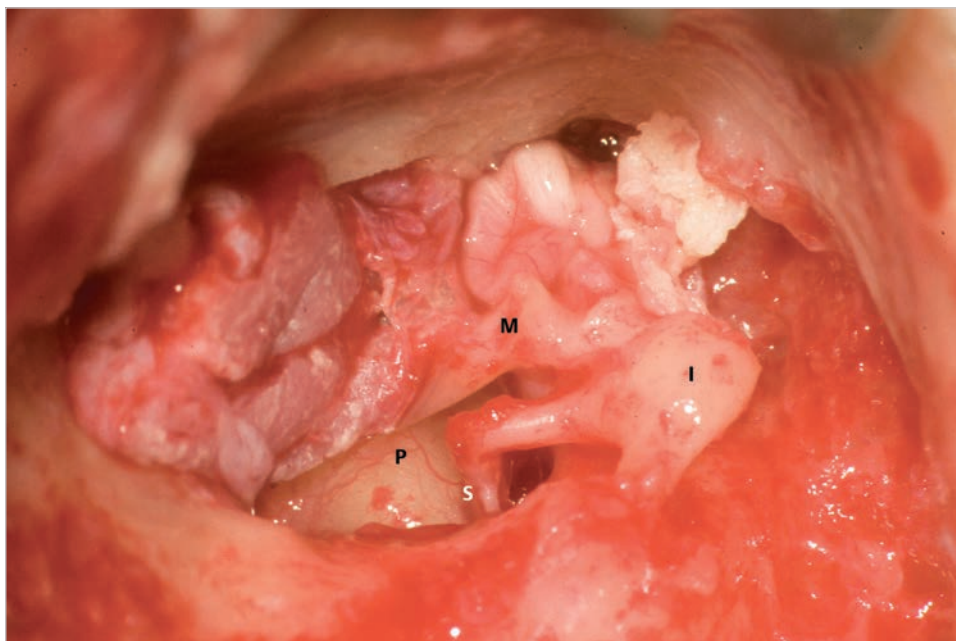


Fig. 7.376 The matrix is carefully dissected from the area under the incus. I, incus; M, malleus; P, promontory; S, stapes.

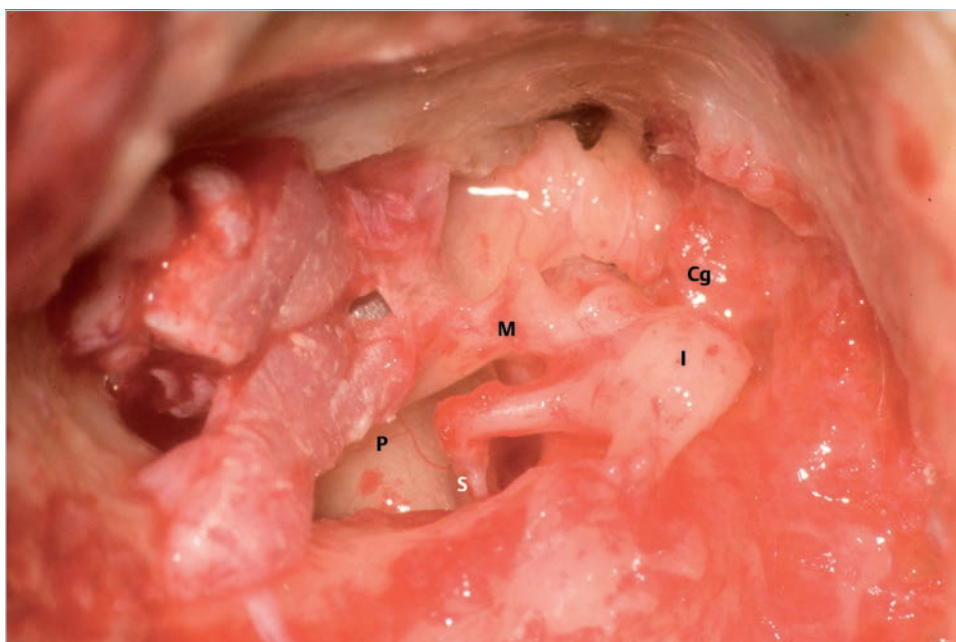


Fig. 7.377 The cholesteatoma is eradicated from the middle ear, and the continuity of the ossicular chain is preserved. The heavy erosion of the head of the malleus serves for good access to the supratubal recess and the medial wall of the attic in this case. The cog separating the supratubal recess from the remaining part of the attic is seen. Cg, cog; I, incus; M, malleus; P, promontory; S, stapes.

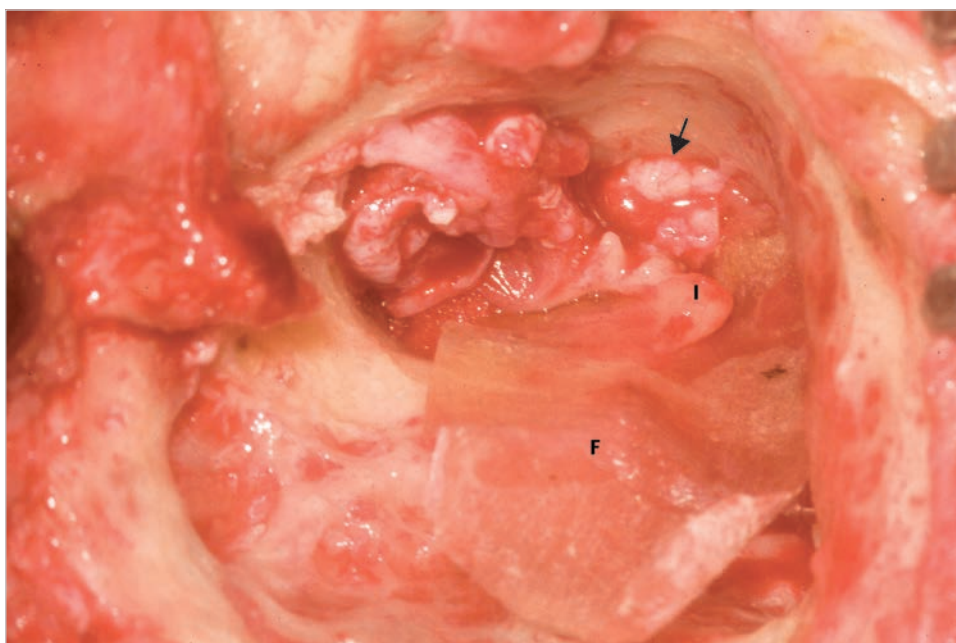


Fig. 7.378 The supratubal recess is obliterated with pieces of cartilage (arrow). The space medial to the body of the incus is also obliterated, and a fascia is placed over the medial wall. The body of the incus is passed through a cut in the fascia. F, fascia; I, incus.

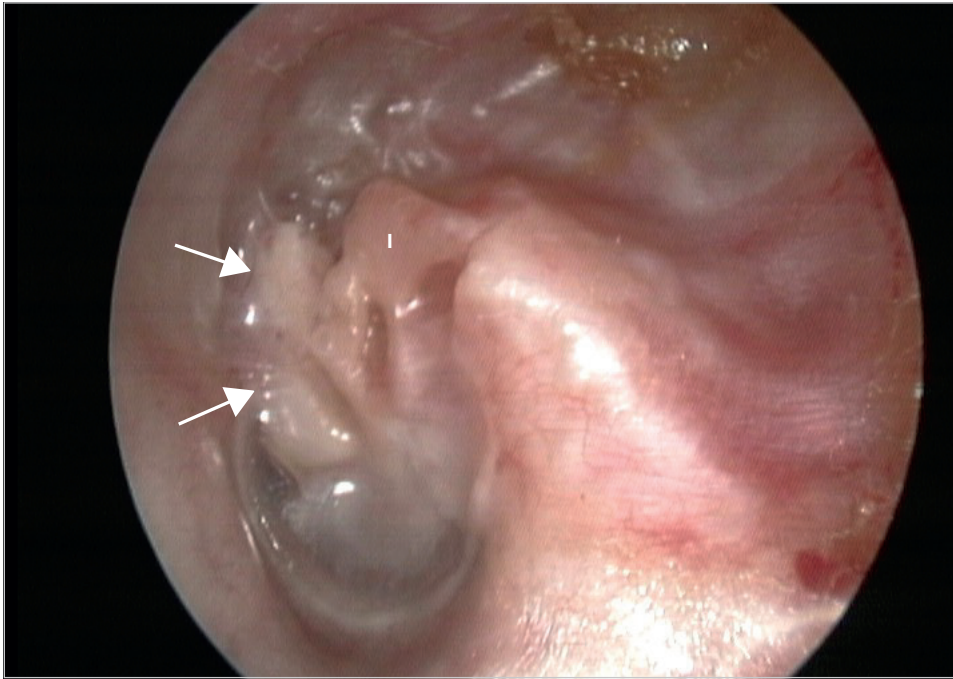


Fig. 7.379 Postoperative otoscopy. The continuity of the ossicular chain is maintained in spite of large erosion in the head of the malleus. Pieces of cartilage used to obliterate the supratubal recess are seen (arrows). I, incus.

Case 7.28 (Left Ear)

See ► Fig. 7.380, ► Fig. 7.381, ► Fig. 7.382, ► Fig. 7.383, ► Fig. 7.384, ► Fig. 7.385, ► Fig. 7.386, ► Fig. 7.387, ► Fig. 7.388, ► Fig. 7.389, ► Fig. 7.390, ► Fig. 7.391.

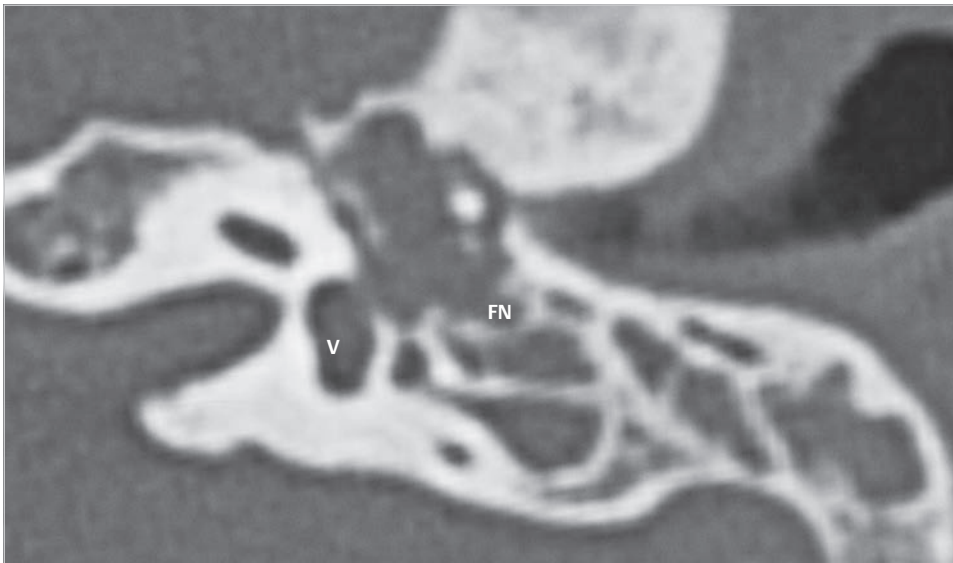


Fig. 7.380 A case of 12-year-old child with epitympanic cholesteatoma is shown. The axial CT shows soft tissue density filling the middle ear. Bone density of both the long process of the incus and the superstructure of the stapes seem to be reduced. Preoperative otoscopy and hearing test show ventilated tympanic cavity with normal hearing. Note the large cells located posteriorly to the facial nerve. FN, facial nerve; V, vestibule.

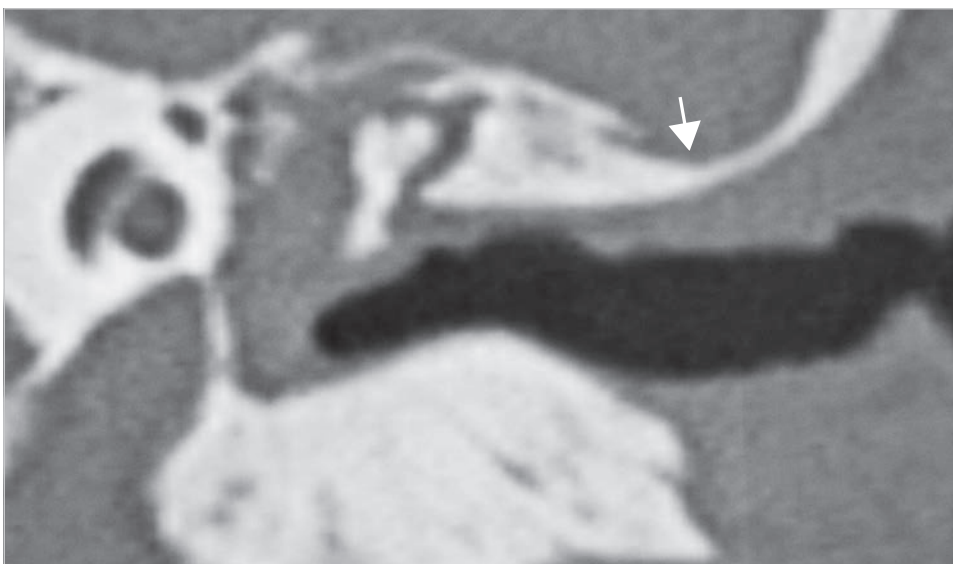


Fig. 7.381 The coronal CT shows very low middle fossa dura (arrow) limiting access to the attic.

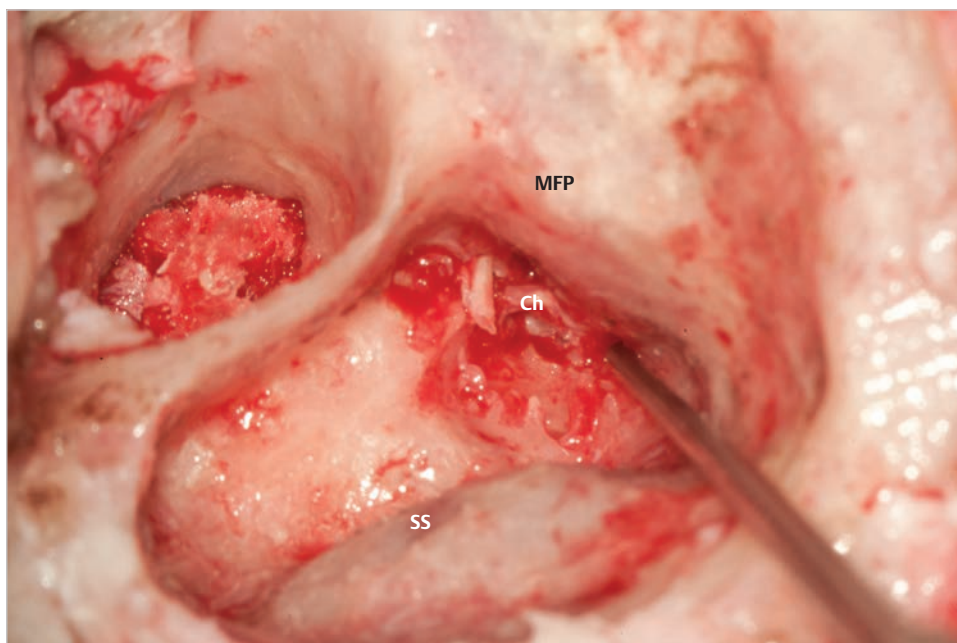


Fig. 7.382 A mastoidectomy is carried out. The middle fossa and the sigmoid sinus are skeletonized, and the bony meatus is calibrated to maximize the approach. Note that the superior meatal wall is almost touching to the middle fossa dura, and dissection of cholesteatoma in the attic from the posterior cavity is not practical. Ch, cholesteatoma; MFP, middle fossa plate; SS, sigmoid sinus.

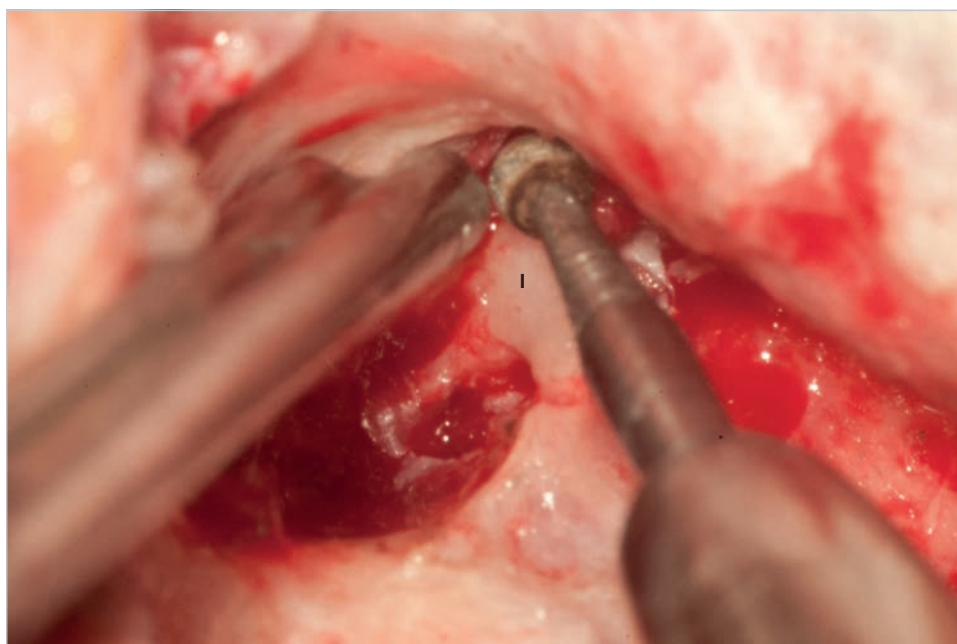


Fig. 7.383 To solve anatomical limitation impeding eradication of cholesteatoma, the surgeon decided to convert this approach to canal wall down. The final bony plate covering the ossicular chain is removed with a curette. The drilling is now advanced anteriorly taking care not to touch the head of the malleus. Small diamond burr that fits the space between the incus and the bony wall and that is not aggressive with the dura is chosen. Diamond burrs are more stable, making this drilling safer than the cutting burrs. I, incus.

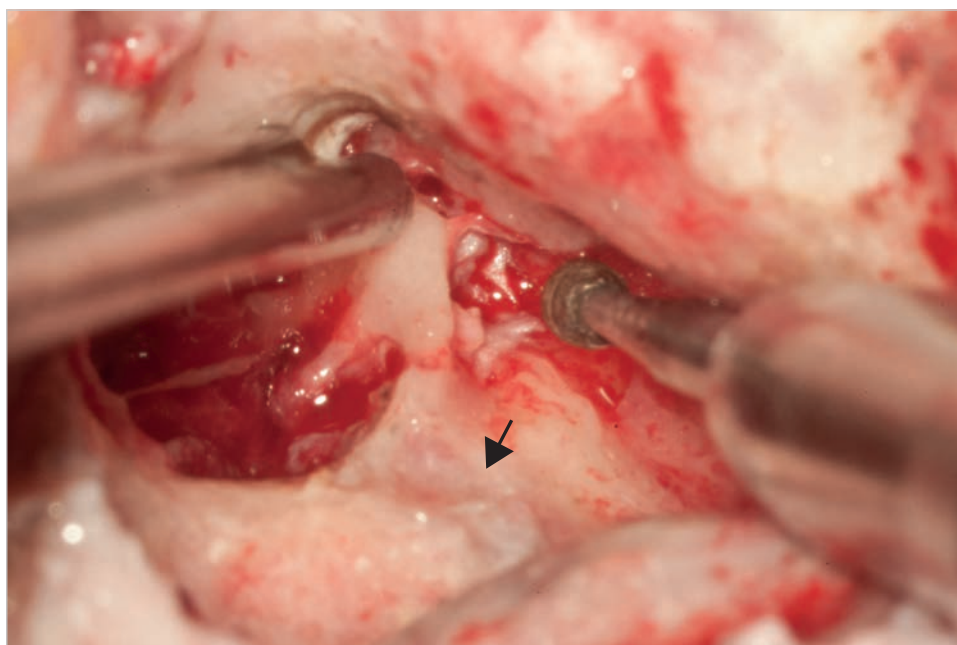


Fig. 7.384 Access to the attic is maximized by moving bony ridges in the middle fossa plate. Note the cholesteatoma located medially to the ossicular chain. In this case, cholesteatoma deeply infiltrates the tympanic sinus and retrofacial cells to reach the area of the mastoid, and can be seen with transparency just behind the facial nerve (arrow).

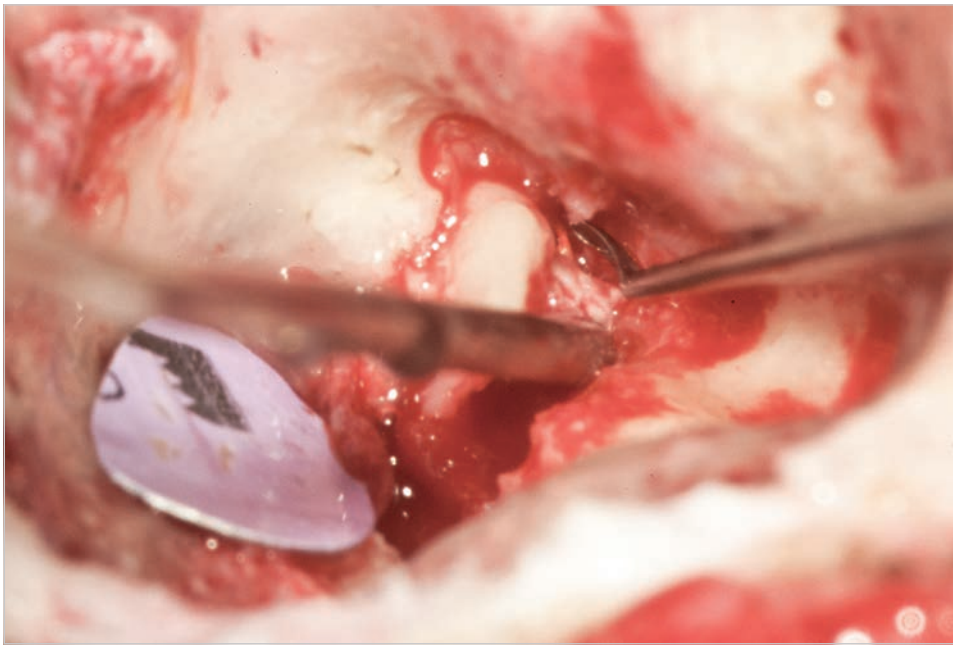


Fig. 7.385 The fossa incudis is opened to gain access to the area medially to the ossicular chain. Cholesteatoma filling this area is pushed carefully from anterior to posterior with the raspatory taking care not to disrupt the matrix.

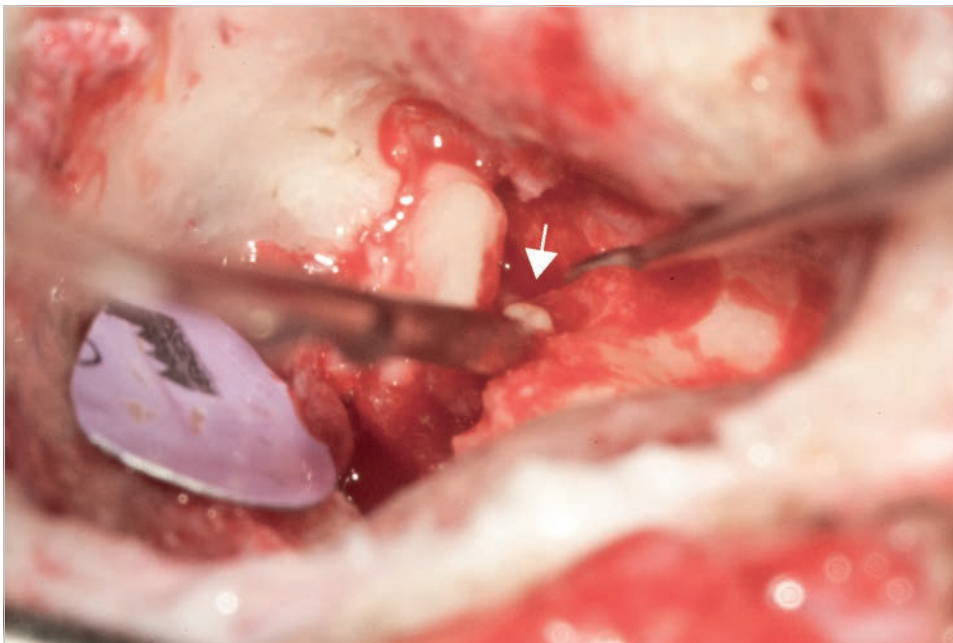


Fig. 7.386 The anterior end of the cholesteatoma is seen (arrow).

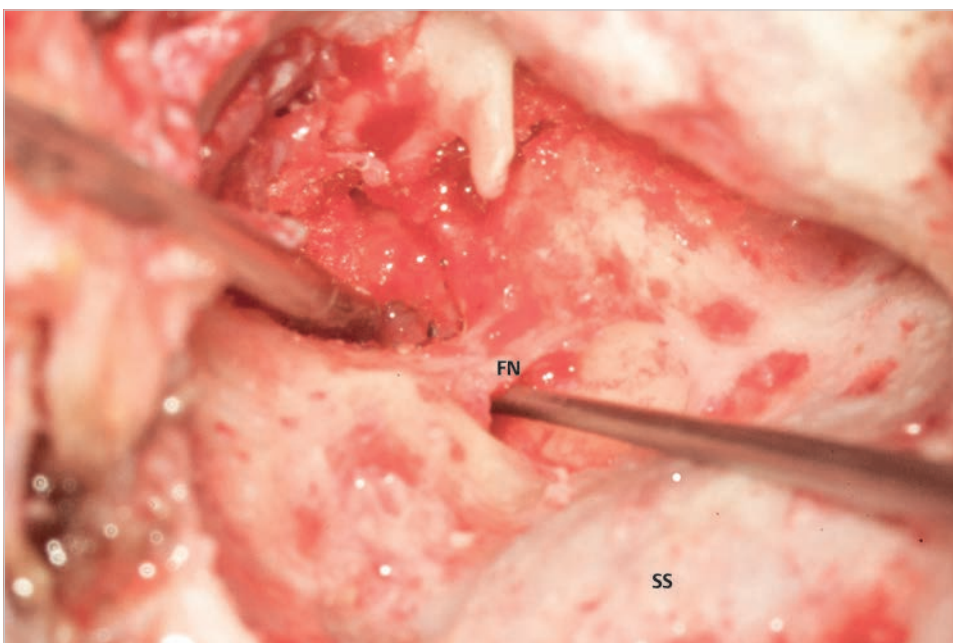


Fig. 7.387 Retrofacial cells are opened and the bone infiltrated by cholesteatoma is drilled. The instrument is introduced to clean the matrix passing under the facial nerve. FN, facial nerve; SS, sigmoid sinus.

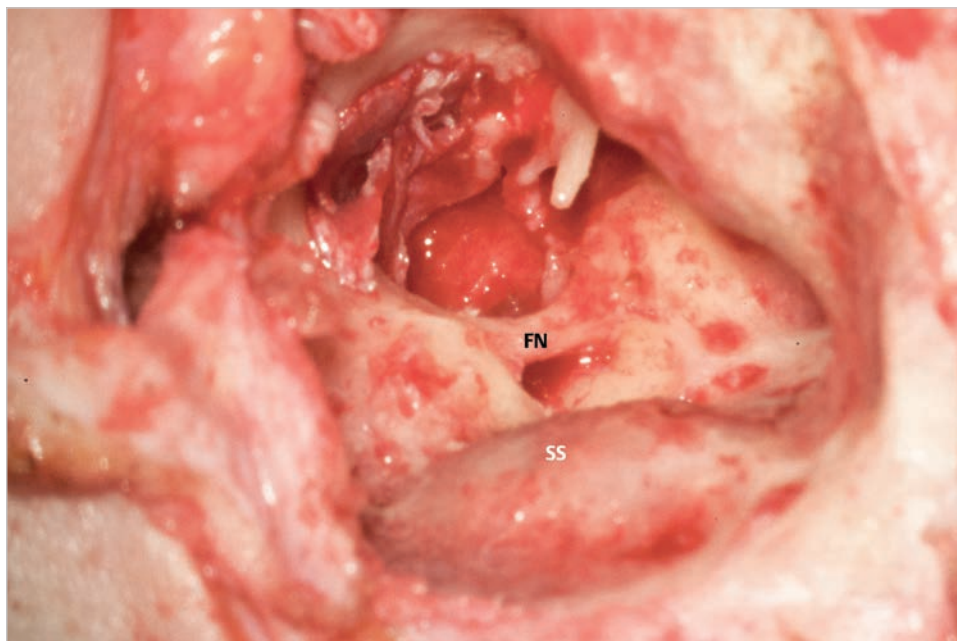


Fig. 7.388 The final shape of the canal wall down cavity is shown. The ossicular chain is preserved, and the retrofacial cells infiltrated by cholesteatoma is removed. FN, facial nerve; SS, sigmoid sinus.

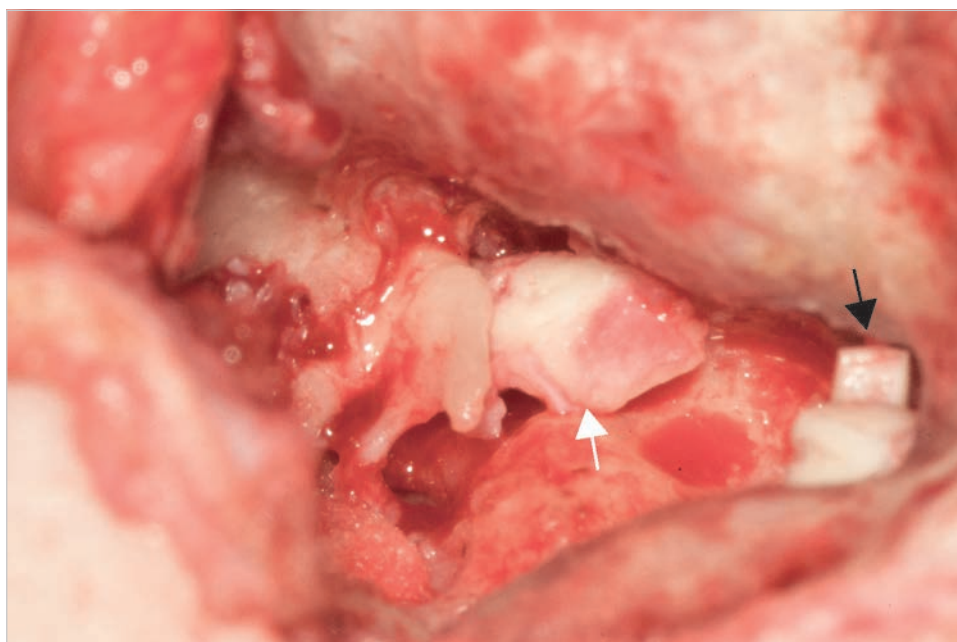


Fig. 7.389 A large piece of conchal cartilage is placed beneath the ossicular chain to prevent postoperative invagination of skin (*white arrow*). The sinodural angle is obliterated with small pieces of cartilage (*black arrow*).

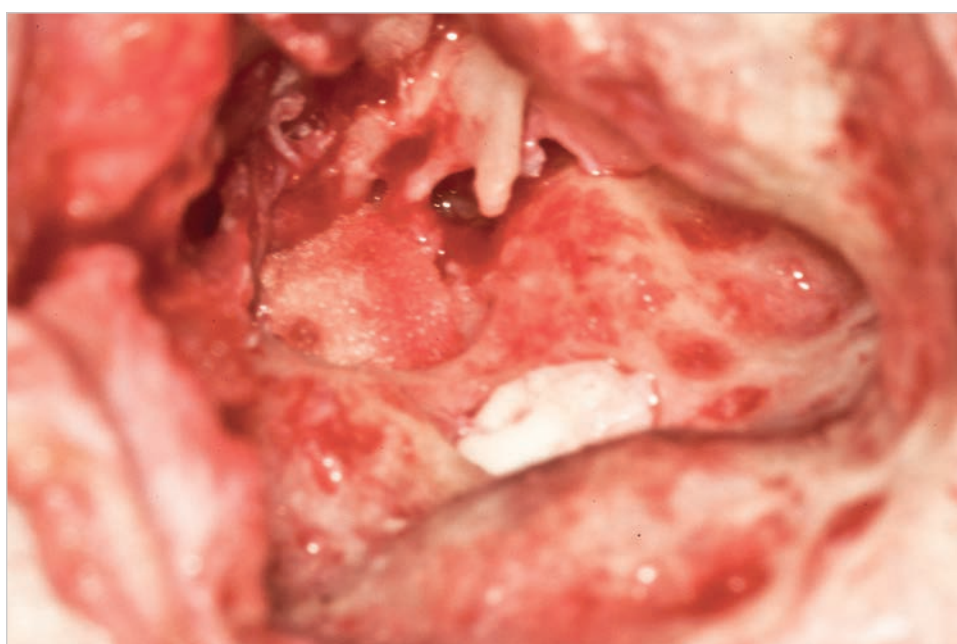


Fig. 7.390 A large opening of retrofacial cells are obliterated with pieces of cartilage.

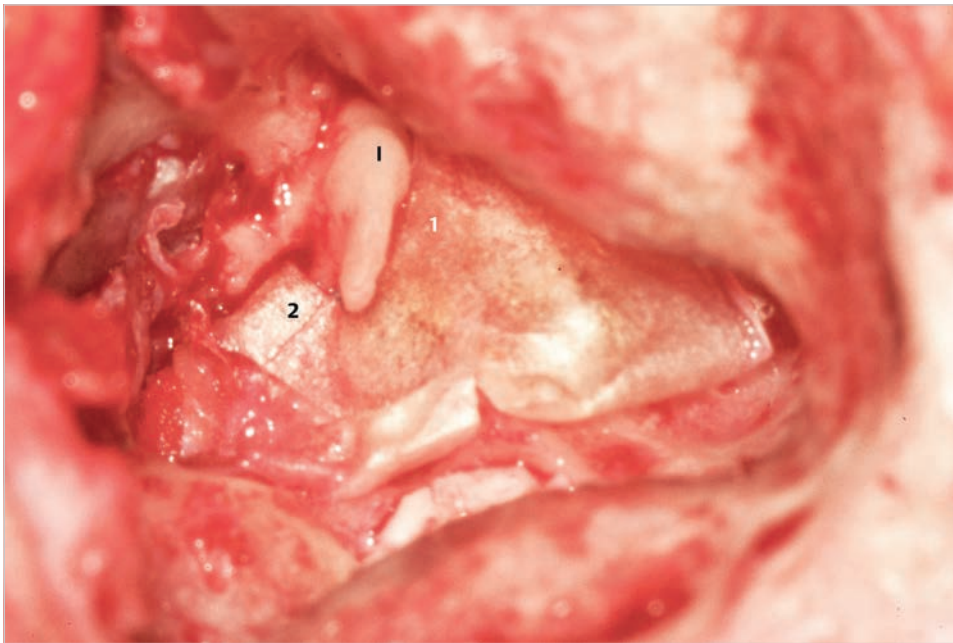


Fig. 7.391 The incus is exteriorized through a cut created in the fascia. The superior tongue of the fascia (1) is inserted under the ossicular chain to cover the cartilage used for obliteration, and the inferior tongue (2) is placed over the long process of the incus. An obliteration of the space medially to the chain and reinforcement of the posterosuperior quadrant of the tympanic membrane with cartilage will follow. I, incus.

7.2.3 Hints and Pitfalls of the Modified Bondy Technique

- The modified Bondy technique forms a part of the main system of operation that must be known by a skilled and experienced surgeon.
- Laterally localized epitympanic cholesteatoma with normal hearing, the intact ossicular chain, and the intact pars tensa is the best indication to adopt this technique.
- The major advantage of this technique over other techniques is a single-stage surgery. That is safer if preservation of the hearing is of prime importance.
- Modifications introduced by our group have tremendously reduced postoperative cavity problems.
- When performed correctly to the right patient, a dry and self-cleaning cavity can be obtained in the majority of the cases (> 95% of our cases).
- Use diamond burrs to stop bleeding from bone without irrigation.
- Always keep in mind that the entire ossicular chain is directly connected to the inner ear. Do not touch the intact ossicular chain with burrs.
- Drilling of the epitympanic area must be carried out very carefully. The drill is moved from medial to lateral or from the area of the chain to elsewhere to avoid touch the malleus and the incus accidentally.
- The last portion of the superior canal wall (the facial bridge) is removed with a curette instead of the burrs.
- Do not leave the anterior buttress. It will favor invagination of the skin anterior to the head of the malleus, which is very difficult to manage.
- Always inspect the middle ear in order to ensure absence of epidermis.
- Leave the tympano-ossicular system intact and untouched as much as possible.
- Insert autologous conchal cartilage beneath the body of the incus and the head of the malleus to avoid retraction that creates deep space medial to these structures.
- Insert a piece of cartilage between the long process of the incus and the manubrium of the malleus if any retraction pocket is formed in the posterosuperior quadrant (even if it is minimal). A retraction in this area may cause incus erosion in a long run.
- If any retraction is formed during follow-up, insert a ventilation tube.
- If protrusion of the anterior canal wall is not so prominent, do not drill it out. This will avoid unnecessary danger to not only the temporomandibular joint but also the ossicular chain.
- Again, meatoplasty is of tremendous importance. In cases of enlarged modified Bondy technique, do not hesitate removal of the malleus and the incus if there is any suspicion of leaving matrix behind them.
- In cases of medial extension in which enlarged modified Bondy technique is attempted, do not hesitate removal of the incus and the malleus if there is any suspicion of leaving matrix behind. Reconstruction of the ossicular chain is usually better for the patient than revision surgery that requires reopening of the cavity via retroauricular incision.

7.3 Radical and Conservative Radical Mastoidectomy

In some cases of cholesteatoma, trial to restore hearing is impractical. Such cases include very bad bone conduction compering to the contralateral ear, and readhesion of the tympanic membrane after multiple middle ear surgeries with very bad hearing. We mainly use subtotal petrosectomy with obliteration in such cases, since the technique, if properly performed, eliminates any possibility of recurrent disease and draining cavity (see Chapter 11). Drawbacks of subtotal petrosectomy are need of abdominal fat, necessity of general anesthesia with longer surgical time, and unfeasibility to wear hearing aids. Therefore, for patients whose only wish is to obtain a safe and trouble-free ear, radical or conservative radical mastoidectomy is a favorable option.

Difference of radical mastoidectomy from open tympanoplasty is complete removal of the middle ear including the sound transmission system except the stapes and eradication of the tubal function. This technique eliminates all the function of middle ear, and is used mainly in elderly patients with preoperative dead ear or non-serviceable ear in which the only goal of surgery is to have a dry and safe ear. In conservative radical mastoidectomy, the tympanic membrane is left untouched, leaving all the structures in the tympanic cavity in situ. The technique is ideal when the tympanic membrane is not inflamed, and no perforation is present. On the other hand, if there is a trouble regarding the eustachian tube such as a large opening of the eustachian tube in the anterior part of the adherent tympanic membrane and the skin invaginating into the eustachian tube, the tube should be closed to obtain a dry and safe cavity. In any cases of cochlear fistula, removal of the skin from the fistula results in total deafness. When the cochlea is eroded in difficult-to-reach area, superiorly deeper to the facial nerve, or inferiorly in the superior aspect of infiltrated hypotympanic cells, drilling of the cochlea is indicated. However, when the cochlea is eroded from lateral by the retracted tympanic membrane, the skin is left in place to preserve residual hearing. In such cases, either radical or conservative radical mastoidectomy is the treatment of choice.

The myringostapediopexy is a condition that retraction of the posterosuperior quadrant of the tympanic membrane erodes the incus, resulting in fusion of the tympanic membrane to the head of the stapes. When there is some remnant of the long process of the incus over the head of the stapes, the situation is called myringo-incudopexy. Air–bone gap may stay minimal in such conditions, resulting in good-to-fair hearing. Reinforcement of the retracted tympanic membrane with cartilage serves better to prevent progression of the disease, and it can be attempted as far as the contralateral ear maintains better hearing. However, when there is only a small air–bone gap, any trial to detach the tympanic membrane from the stapes may cause deterioration of

hearing. Surgery on a better hearing ear with myringostapediopexy with minimal air–bone gap, modified radical mastoidectomy can be a good option.

Indications
• Multiple recurrences in not-very-large mastoid with no serviceable hearing • Poor general condition with no serviceable hearing • Elderly with no wish to restore hearing • Elderly to whom planning of second-stage surgery is impractical • Cochlear fistula in its lateral aspect • Presence of middle ear cholesteatoma in difficult-to-reach areas, for example, deep sinus tympani • Cholesteatoma with intracranial complications • Better hearing ear with myringostapediopexy with minimal air–bone gap (conservative radical)

7.3.1 Surgical Steps

1. Mastoidectomy and removal of the posterior canal wall are completed as in CWD (open) tympanoplasty described in the beginning of this chapter. In conservative radical mastoidectomy, the tympanic cavity may be opened inferiorly to make sure absence of residual disease. However, the tympanic membrane fusing to the stapes should be left untouched. Remnant of the incus and the head of the malleus can be removed if there is any inaccessible area behind.
2. In rare cases, large dips in the cavity are filled with cartilage and/or bone paste. The area should be covered with fascia at the end of surgery.
3. If cochlear fistula is present in cases of cholesteatoma, the matrix is left in place to avoid sensorineural hearing loss. If cholesteatoma locates in the difficult-to-reach area such as deep sinus tympani, the area is exteriorized. These areas with epidermis should not be covered with the fascia at the end of operation.
4. A meatoplasty is performed, and conchal cartilage is harvested (see Meatoplasty earlier in this chapter). The conservative radical mastoidectomy is accomplished at this stage.
5. In radical mastoidectomy, the ossicles are removed, except for the stapes. All the middle ear mucosa is removed to avoid any drainage from the middle ear except a cochlear fistula.
6. The eustachian tube is then obliterated with a piece cartilage, and the tube is further obliterated with soft tissue such as periosteum.
7. Fascia is placed over the middle ear with no air space left medially. The cavity is covered as widely as possible with the temporalis fascia. However, care should be taken not to put the fascia over the epidermis if it is left in place. Otherwise, residual cholesteatoma would be formed.
8. Remnant of the tympanic membrane and the meatal skin flap are replaced over the fascia and the cavity wall.

Case 7.29 (Right Ear)

See ► Fig. 7.392, ► Fig. 7.393, ► Fig. 7.394, ► Fig. 7.395, ► Fig. 7.396, ► Fig. 7.397, ► Fig. 7.398, ► Fig. 7.399, ► Fig. 7.400, ► Fig. 7.401.



Fig. 7.392 A case of cholesteatoma unusable hearing with adherent tympanic membrane with unusable hearing in elderly. Canal wall down mastoidectomy is started to identify the sigmoid sinus and the middle fossa plate. The cholesteatoma invaginated into the middle ear through the posterosuperior quadrant (*arrow*). No pathology is seen in the mastoid. The meatal skin is cut circumferentially to calibrate the anterior and inferior walls. MFP, middle fossa plate; SS, sigmoid sinus.

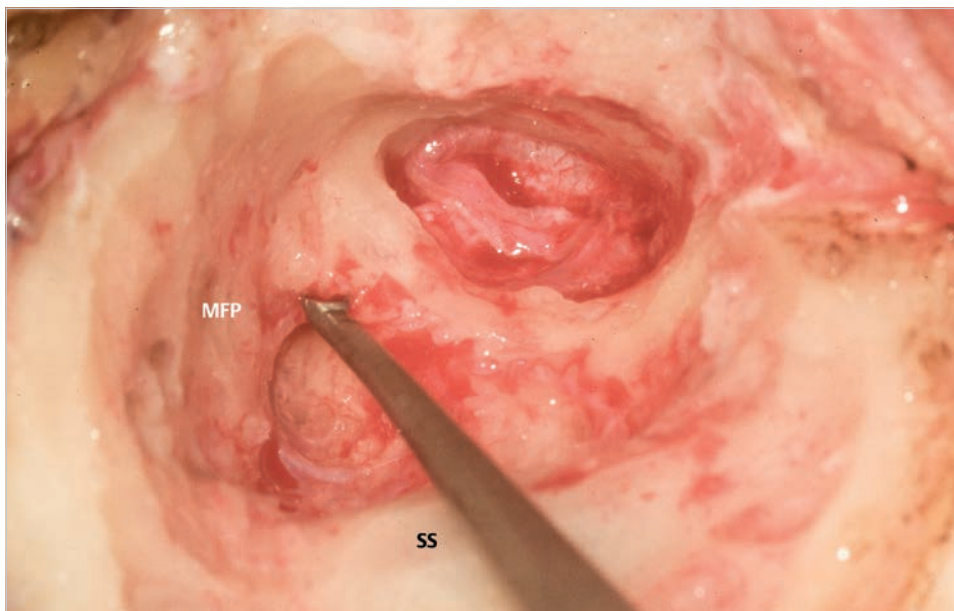


Fig. 7.393 The posterior wall is lowered to reach the level of the tympanic membrane and to open the attic. The bony bridge covering the ossicular chain can be removed with a curette after thinning it. MFP, middle fossa plate; SS, sigmoid sinus.

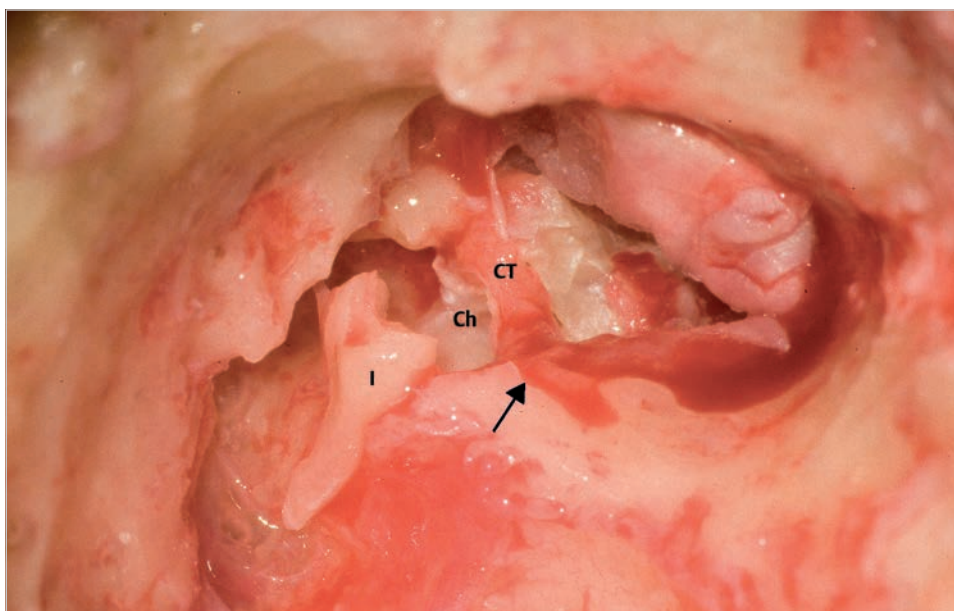


Fig. 7.394 The attic is partially opened. The body of the incus is removed to dissect the matrix beneath it. The long process of it is missing. The chorda tympani nerve emerging from the canaliculus chordae running laterally to the cholesteatoma is seen (*arrow*). Ch, cholesteatoma; CT, chorda tympani; I, incus.

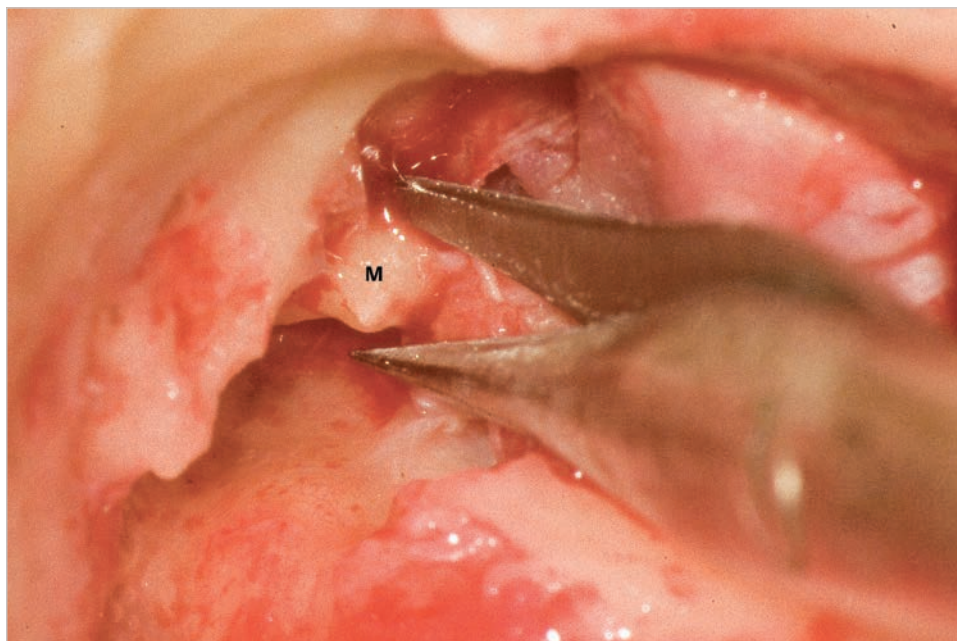


Fig. 7.395 To open the area anteriorly to the head of the malleus, the head is cut with sharp scissors. The procedure serves to prevent invagination of the skin under the head postoperatively. M, head of malleus.

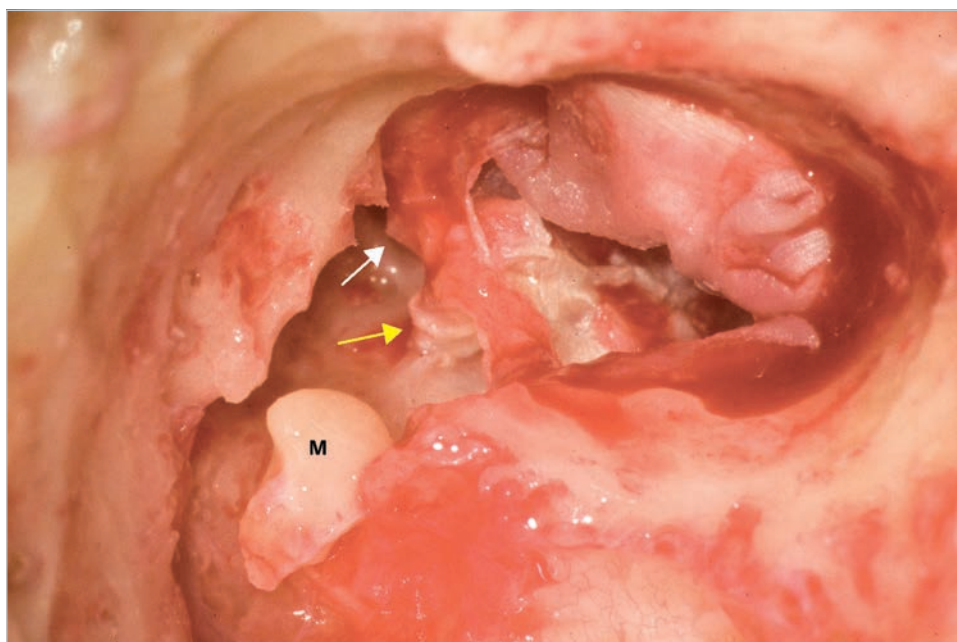


Fig. 7.396 The head of the malleus is removed. An opening of the tympanic cavity (*white arrow*) is identified anteriorly to the tendon of the tensor tympani muscle (*yellow arrow*). The overhanging bone covering the anterior attic should be removed. M, head of malleus.



Fig. 7.397 The facial ridge should be lowered sufficiently including its anterior aspect to allow access to the posterior wall of the tympanic cavity postoperatively. The tympanic cavity is entered from inferior to verify absence of disease. A large jugular bulb protruding from the floor of the tympanic cavity is seen. JB, jugular bulb.

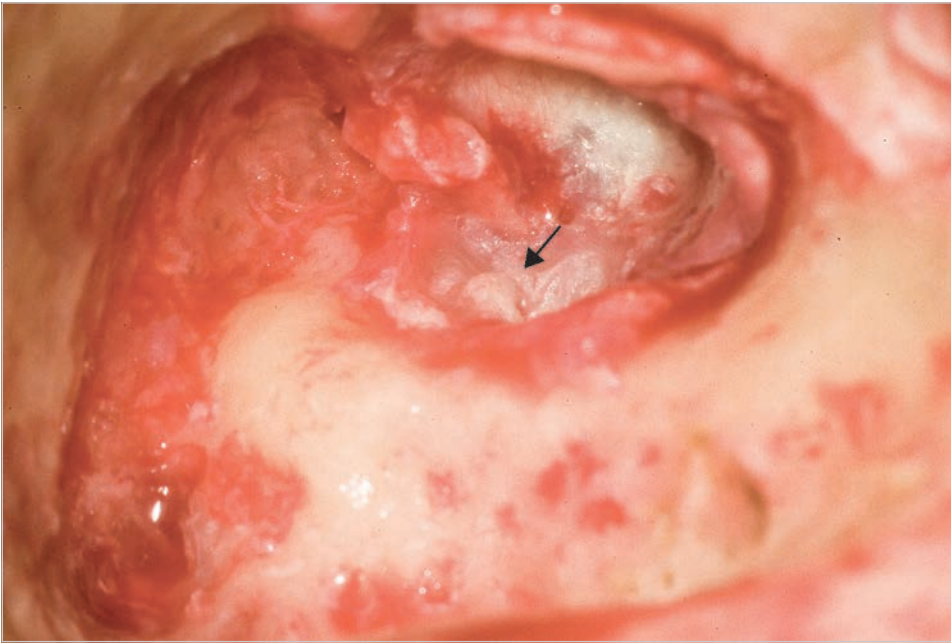


Fig. 7.398 The final shape of the area around the tympanic membrane is seen. The superstructure of the stapes protrudes in the posterosuperior quadrant (*arrow*). Note that the anterior attic is fully accessible.



Fig. 7.399 A soft tissue flap is prepared using the triangular soft tissue flap created during the retroauricular soft tissue incision.



Fig. 7.400 The flap is dissected from the underlying meatal tissue in the way that it has a pedicle inferiorly. F, soft tissue flap.

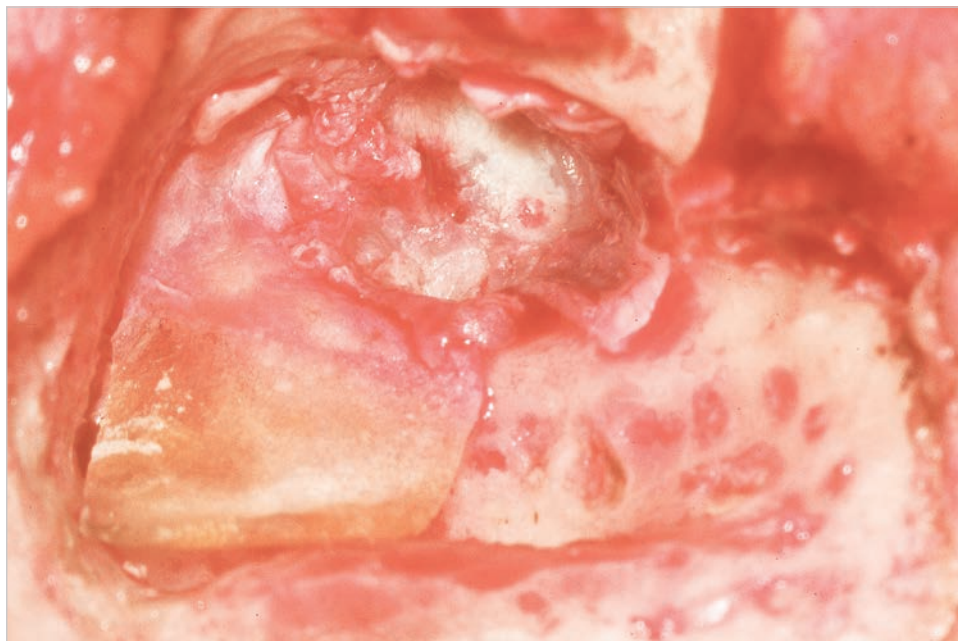


Fig. 7.401 After closing the opening of the tympanic cavity anteriorly to the tendon of the tensor tympani muscle (► Fig. 7.396) with cartilage, a piece of fascia is placed to cover the medial wall of the cavity, and the skin and the tympanic membrane are placed back over the fascia. The area of the mastoid tip will be covered with the soft tissue flap.

Case 7.30 (Left Ear)

See ► Fig. 7.402, ► Fig. 7.403, ► Fig. 7.404, ► Fig. 7.405, ► Fig. 7.406, ► Fig. 7.407, ► Fig. 7.408.

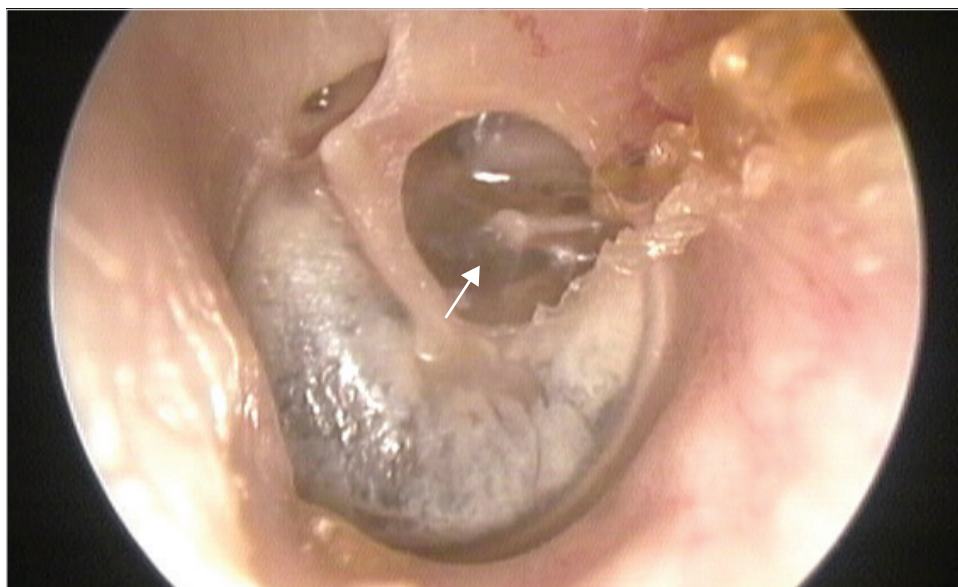


Fig. 7.402 The patient suffered from bilateral cholesteatoma, and the contralateral ear has already been operated with some postoperative air–bone gap. In spite of disruption of the ossicular chain due to erosion of the long process of the incus, natural myringostapediopexy (arrow) makes this side better hearing ear. Therefore, preservation of the hearing of this ear is of primary concern.

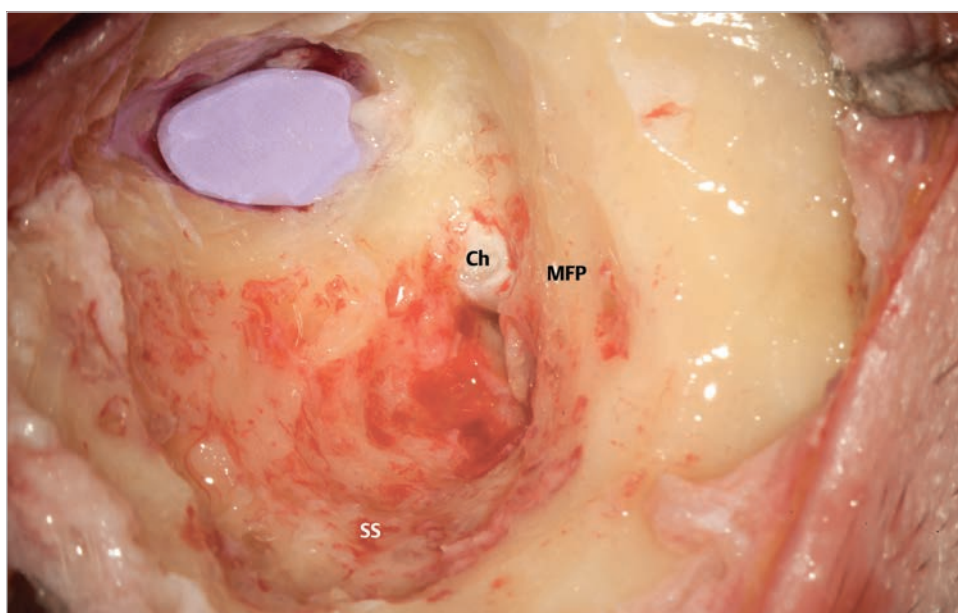


Fig. 7.403 According to our strategy, bilateral cholesteatoma is indication of canal wall down procedure (see *Indications* at the beginning of this chapter). The tympanomeatal flap is detached from the bony wall, and wide access to the mastoid and the tympanic cavity is established by identifying the sigmoid sinus posteriorly and middle fossa plate superiorly. Note absence of sharp bony edges in the cavity. The cholesteatoma reaching the antrum is started to be seen. Ch, cholesteatoma; MFP, middle fossa plate; SS, sigmoid sinus.

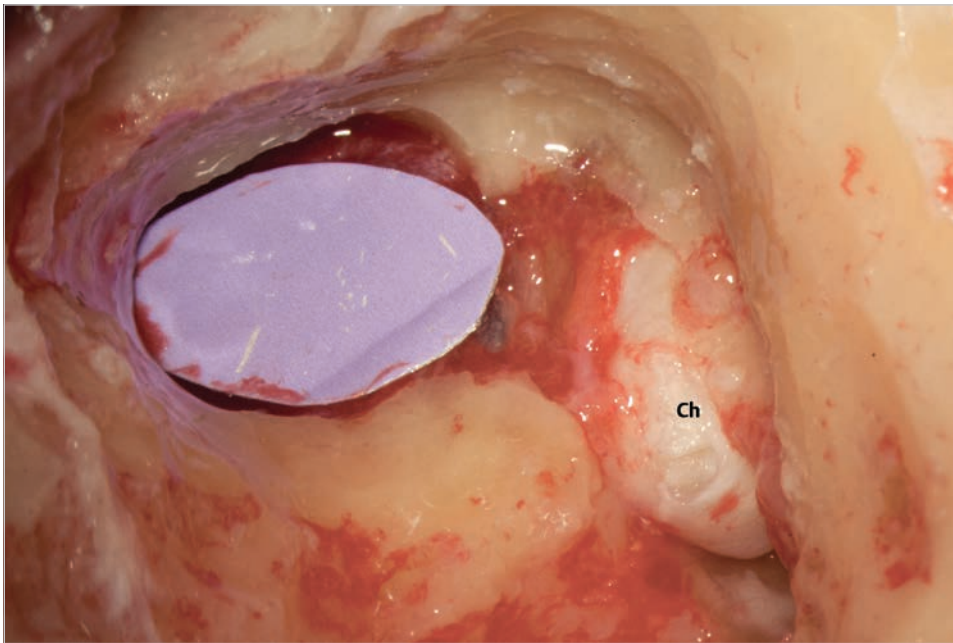


Fig. 7.404 The bony meatus is calibrated, and the facial bridge is thinned with burrs and removed with a curette. The attic is partially opened to further expose cholesteatoma. Ch, cholesteatoma.

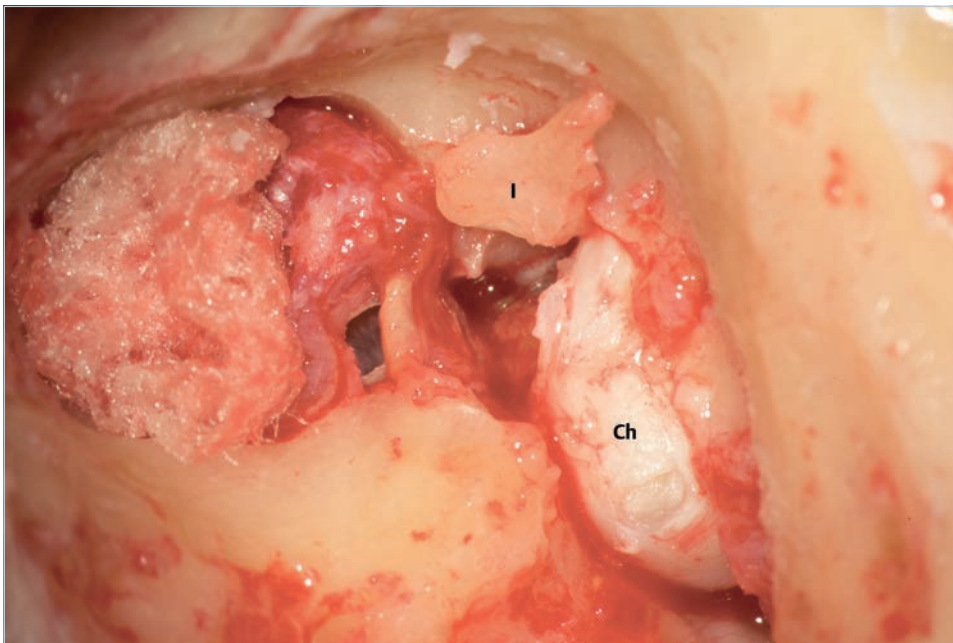


Fig. 7.405 The incus dissociated from the stapes due to erosion of the long process is removed from the attic. Ch, cholesteatoma; I, incus.

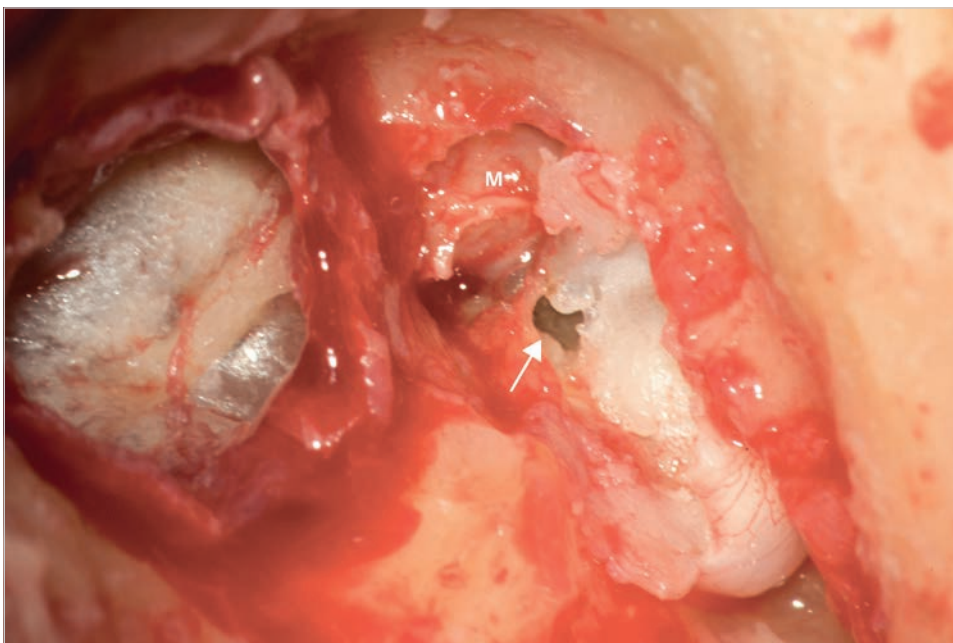


Fig. 7.406 Cholesteatoma passing under the head of the malleus (arrow) is shown. M, malleus.

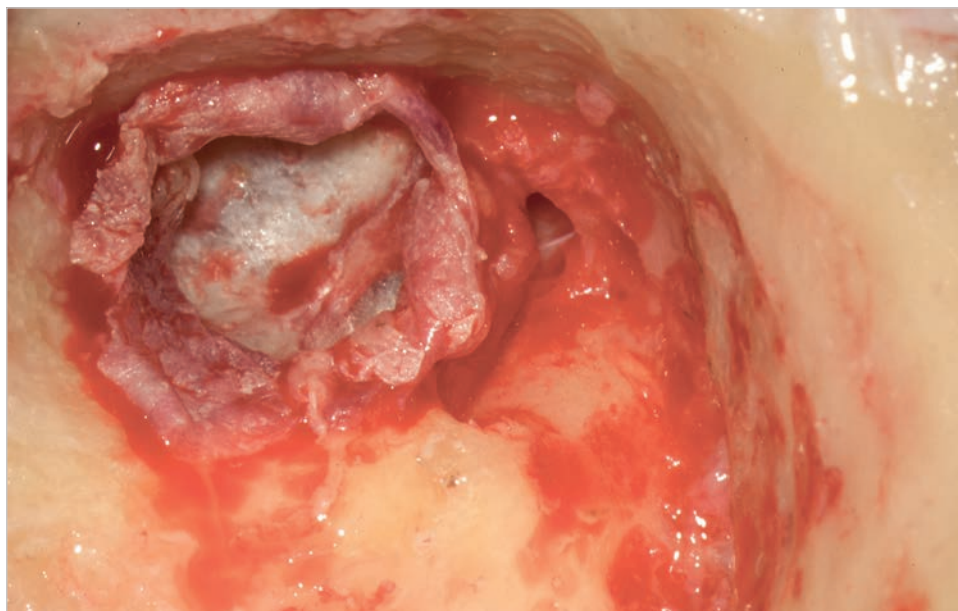


Fig. 7.407 The head of the malleus is cut, and the cholesteatoma is eradicated from the middle ear.

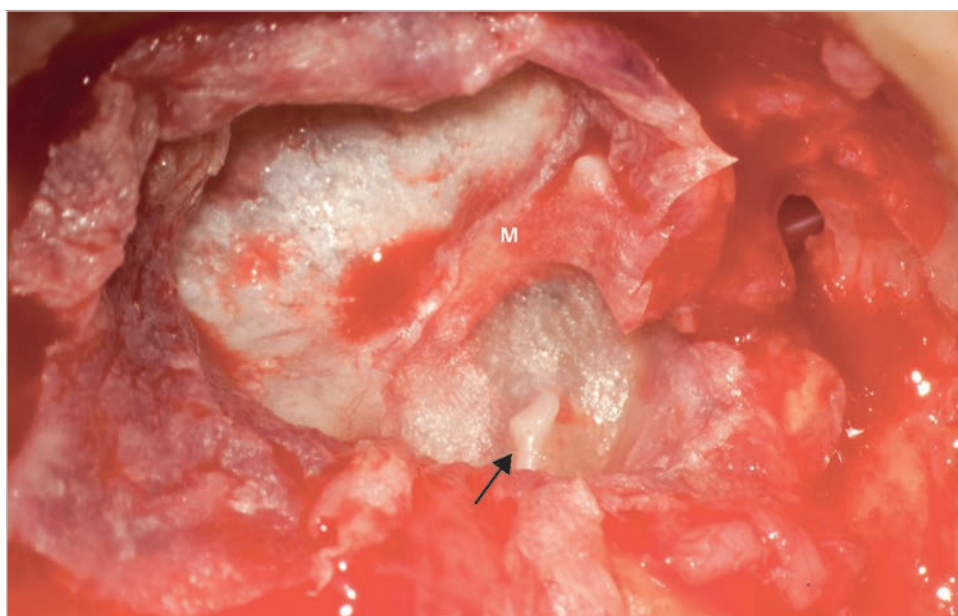


Fig. 7.408 Close view of the tympanic membrane. A retraction of the posterosuperior quadrant forms myringostapediopexy (*arrow*), resulting in limited air–bone gap. To preserve preoperative hearing, the posterosuperior quadrant is left untouched. The cavity will be partially obliterated with pieces of cartilage, and covered with temporalis fascia. M, head of malleus.

Case 7.31 (Right Ear)

See ► Fig. 7.409, ► Fig. 7.410, ► Fig. 7.411, ► Fig. 7.412, ► Fig. 7.413, ► Fig. 7.414, ► Fig. 7.415.



Fig. 7.409 A case of cochlear fistula in radical cavity. Otoscopy after cleaning shows adhesion of the tympanic membrane to the medial wall, and accumulation of debris in inaccessible area of the mastoid. The facial nerve courses in the middle of the cavity. Fistulae in the lateral semicircular canal (*white arrow*) and the cochlea (*black arrow*) are identified superiorly to the facial nerve and anteriorly to the promontory, respectively, as bluish areas. FN, facial nerve.

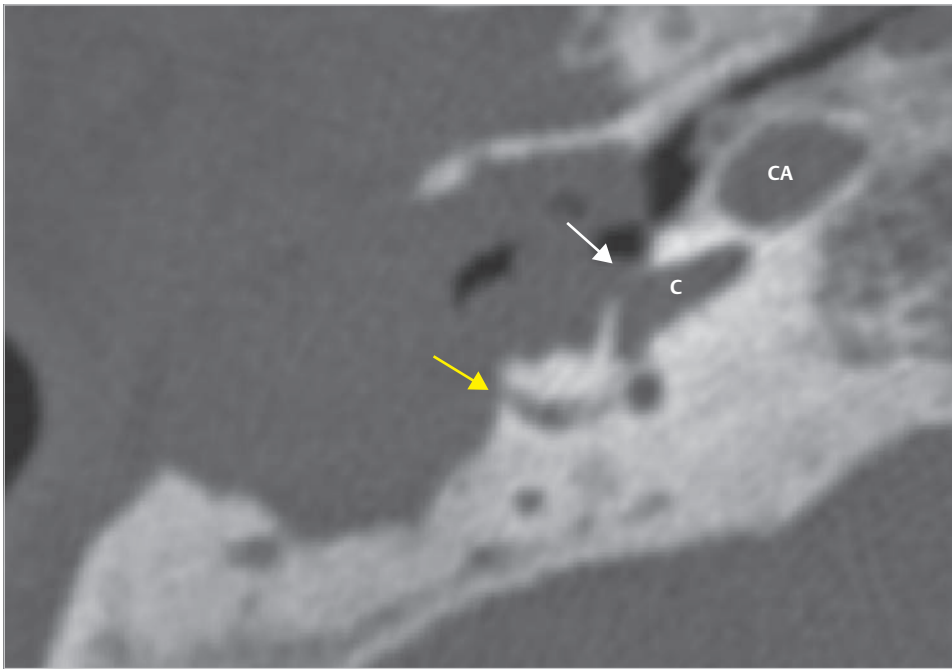


Fig. 7.410 The axial CT shows presence of large labyrinthine fistulae in both cochlea (*white arrow*) and the lateral semicircular canal (*yellow arrow*). In spite of presence of these large fistulae, the patient maintained decent bone conduction. Since the contralateral ear shows mixed deafness due to tympanosclerotic change, preservation of the inner ear function in this ear is indicated. Total deafness is mandatory if the skin covering the cochlear fistula is removed. C, cochlea; CA, carotid artery.

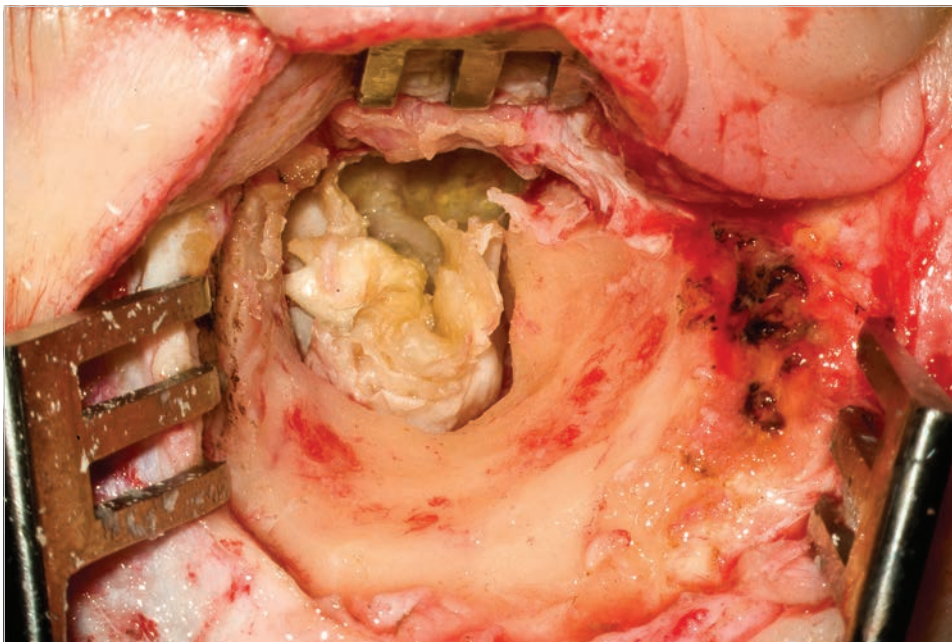


Fig. 7.411 The cortical bone is removed to open the mastoid filled with cholesteatoma. Sharp edges should be removed, and the mastoid should be opened widely.

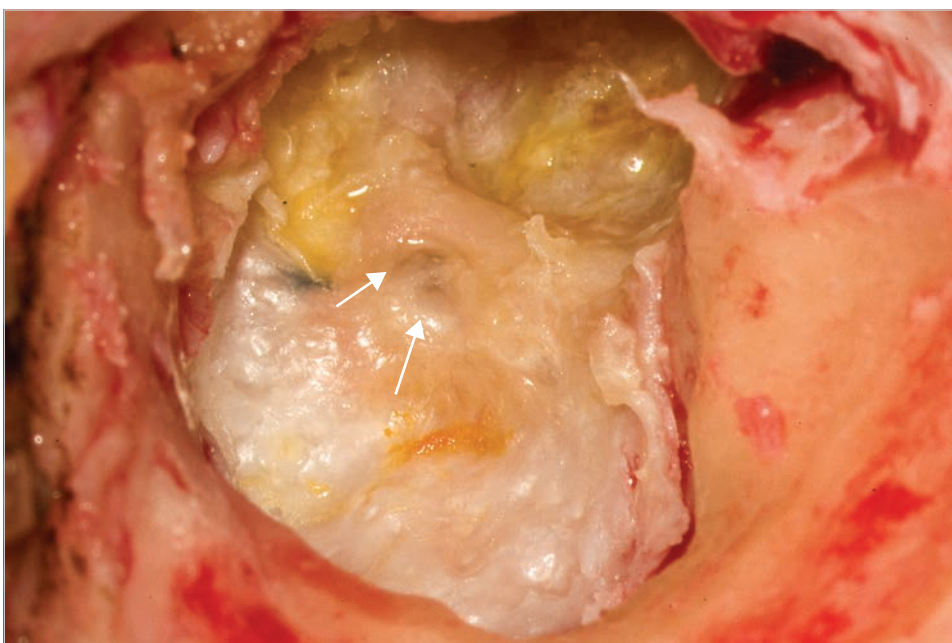


Fig. 7.412 The majority of the debris is removed from the cavity. The labyrinthine fistulae in the lateral semicircular canal is identified (*arrows*).

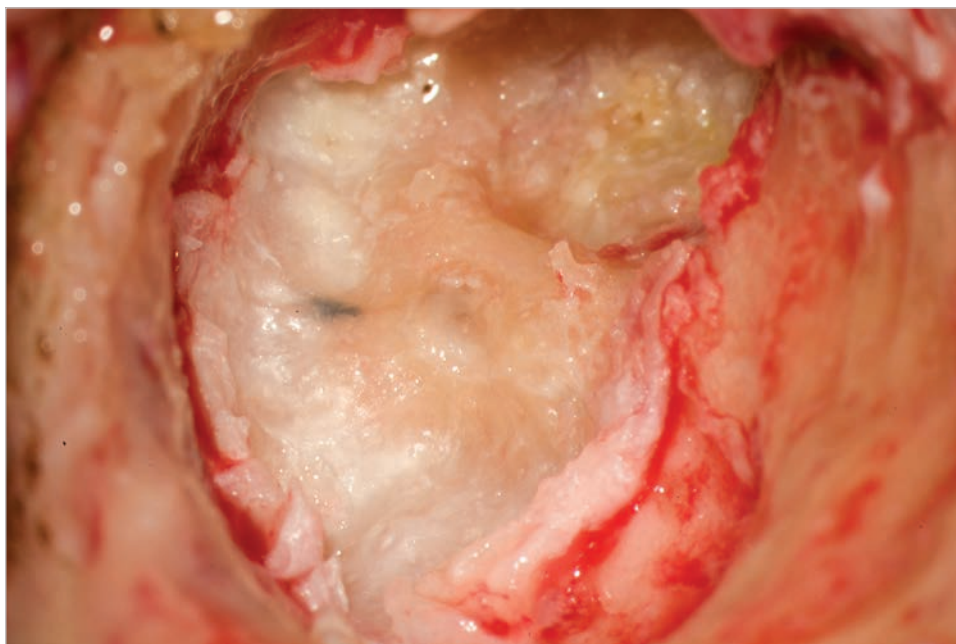


Fig. 7.413 The adherent tympanic membrane is not elevated, and the skin covering the labyrinthine fistula in the lateral semicircular canal is left untouched. The cavity is saucerized by lowering high facial ridge, and bony spurs in the cavity. Since the majority of the skin covering the cavity is not inflamed, it is used to cover the saucerized cavity. Covering of the exposed bone with fascia follows.



Fig. 7.414 A dry and safe cavity is obtained postoperatively. Bone conduction is preserved. Labyrinthine fistulae in the basal turn of cochlea (*black arrow*) and the lateral semicircular canal (*white arrow*) can be identified under the skin. FN, facial nerve.

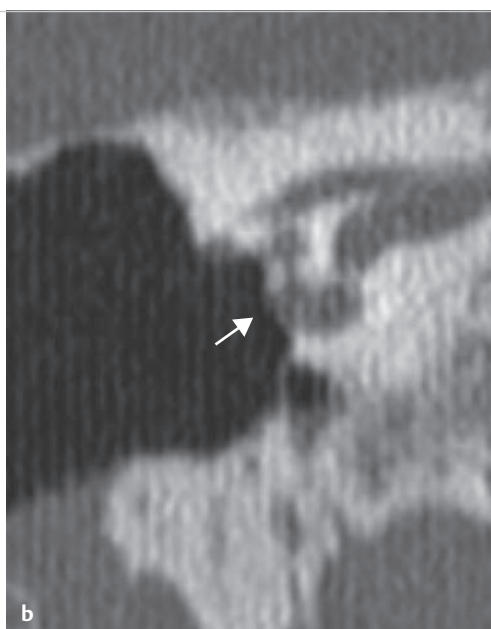


Fig. 7.415 The postoperative axial CT demonstrates large fistula in the lateral semicircular canal (**a**) and coronal CT in the basal turn of the cochlea (**b, arrow**). Note the clean cavity demonstrated in both slices.

7.4 Second-Stage Surgery in Canal Wall Down Technique

After canal wall tympanoplasty without ossicular reconstruction, the second-stage surgery is required to reconstruct the ossicular chain and to explore the tympanic cavity except the cases with good postoperative hearing by chance and with little worry for residual disease. If the shapes of the cavity and the meatus stay good, the surgery can be performed in much less invasive manner, through the largest possible ear speculum under local anesthesia (transmeatal approach) in most of the cases. Even though there is apparent cholesteatoma in the tympanic cavity, the surgery can be conducted through an ear speculum in the majority of the cases. In rare cases, possibility of wider approach remains, and it should be informed preoperatively.

In second-stage surgery it is essential that the cavity is trouble-free, and covered by noninflammatory skin. Even though the main focus of the surgery is ossiculoplasty and exploration of the tympanic cavity to check any residual lesion, small corrections such as removal of small erosion, repair of small perforation, and reinforcement of retraction can be added. In transmeatal approach, the approach is established via the largest possible ear speculum. With appropriate meatoplasty, the approach is wide enough to allow most of procedures required in the tympanic cavity. Meticulous care should be taken during skin incision and

flap elevation not to damage the facial nerve, which might be exposed without bony shell. Evaluation of computed tomography (CT) after the first stage helps to know aeration of the tympanic cavity and anatomy that is modified after the first-stage surgery. In this chapter, only cases with residual cholesteatoma are shown.

7.4.1 Surgical Steps of Transmeatal Approach

1. A superiorly based, sufficiently long tympanomeatal flap should be created, since the flap shrinks by the end of surgery. The cut runs from 3 o'clock to 9 o'clock position, anteriorly from the area of the eustachian tube, crossing the facial nerve, running the area posterior to the mastoid segment of the nerve, and reaches to the level of the lateral semicircular canal. The incision should be placed about 1 cm posteriorly to the facial nerve, and minimum distance from the tympanic membrane should be more than 1 cm (► Fig. 7.416). To avoid facial nerve injury, it is important to probe the course of the facial nerve and to verify bony shell covering it.
2. The flap is elevated toward the epitympanum, from inferior to superior, to allow gradual anatomical identification of the promontory, the round window, the stapes, and finally, the tympanic segment of the facial nerve (► Fig. 7.417). In this way, good position of the tympanic membrane is maintained and the risk of injuring the facial nerve and the stapes is reduced.

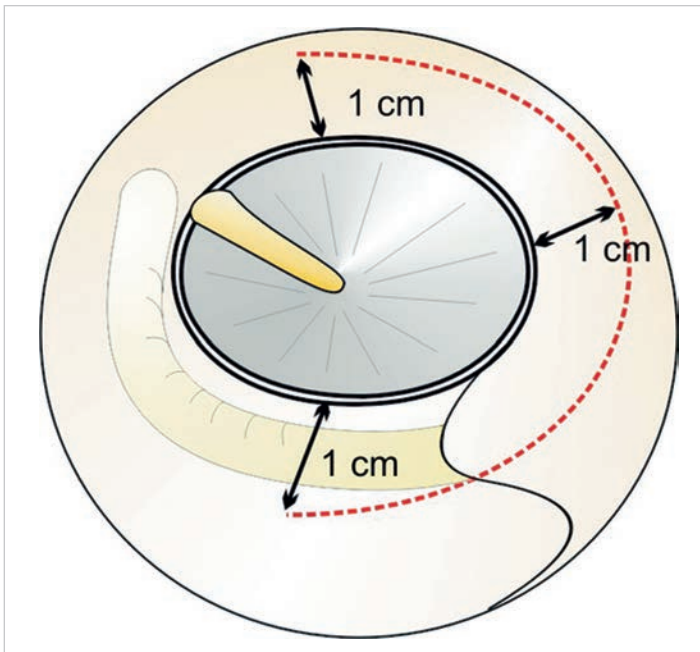


Fig. 7.416 Incision line for transmeatal approach in the canal wall down cavity. The line covers inferior half of the tympanic membrane, running from the area of the eustachian tube to the area posterior to the mastoid segment of the facial nerve. Distance from the tympanic membrane should be more than 1 cm in all directions.

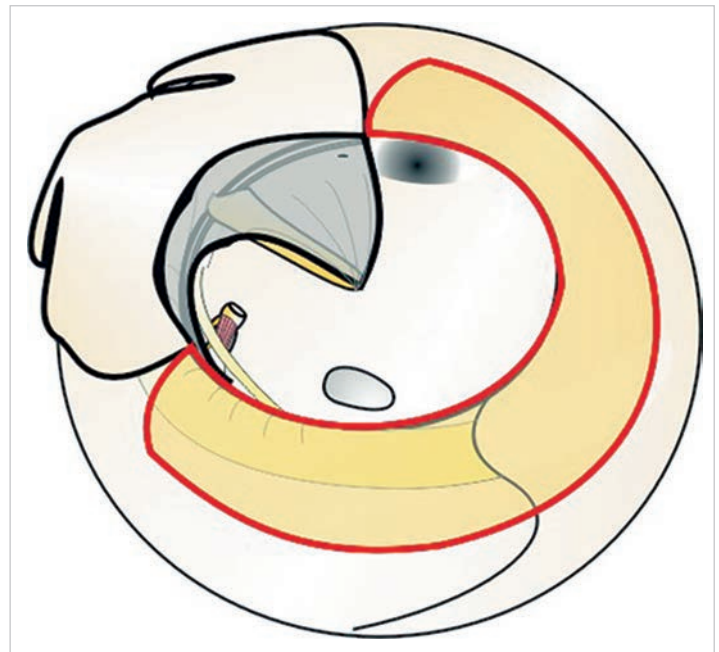


Fig. 7.417 The tympanic membrane is elevated from inferior to superior to identify safe structures such as hypotympanic cells and the promontory first, then to advance to fragile structures such as the stapes and the facial nerve.

Case 7.32 (Left Ear)

See ▶ Fig. 7.418, ▶ Fig. 7.419, ▶ Fig. 7.420, ▶ Fig. 7.421, ▶ Fig. 7.422, ▶ Fig. 7.423, ▶ Fig. 7.424, ▶ Fig. 7.425, ▶ Fig. 7.426, ▶ Fig. 7.427, ▶ Fig. 7.428, ▶ Fig. 7.429, ▶ Fig. 7.430, ▶ Fig. 7.431, ▶ Fig. 7.432.



Fig. 7.418 A case of second-stage surgery after canal wall down tympanoplasty for cholesteatoma limited to the tympanic cavity is shown. The reconstructed tympanic membrane is well epithelialized, and easy to access due to the canaloplasty in the first stage.



Fig. 7.419 A U-shaped incision covering from the anterior to posterior walls are conducted. Using cottonoid, the meatal skin is carefully elevated toward the tympanic membrane.

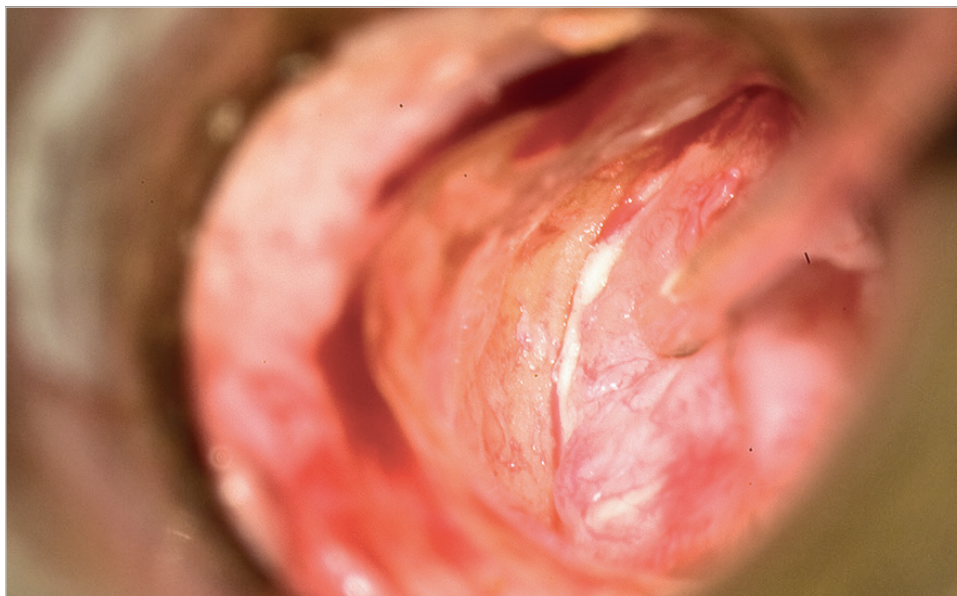


Fig. 7.420 The fibrous annulus indicates the end of the meatal skin, and the tympanic cavity is safely entered by detaching it.

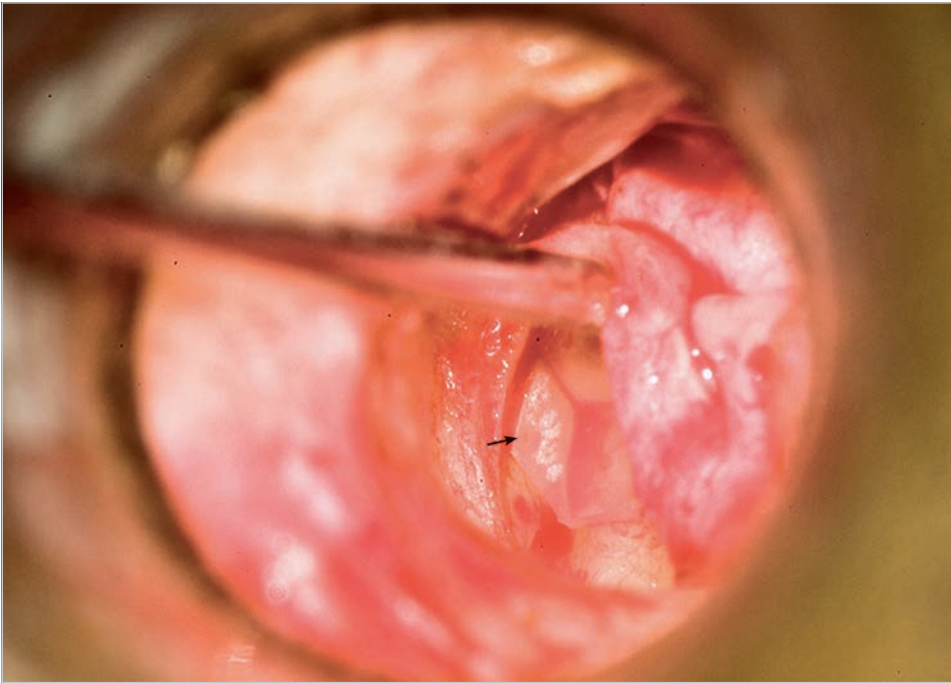


Fig. 7.421 In the majority of cases, it is safer to open the tympanic cavity from inferior, since no important structures except the jugular bulb is present at this location. The inferior end of the Silastic sheeting placed in the first stage surgery is seen (*arrow*).

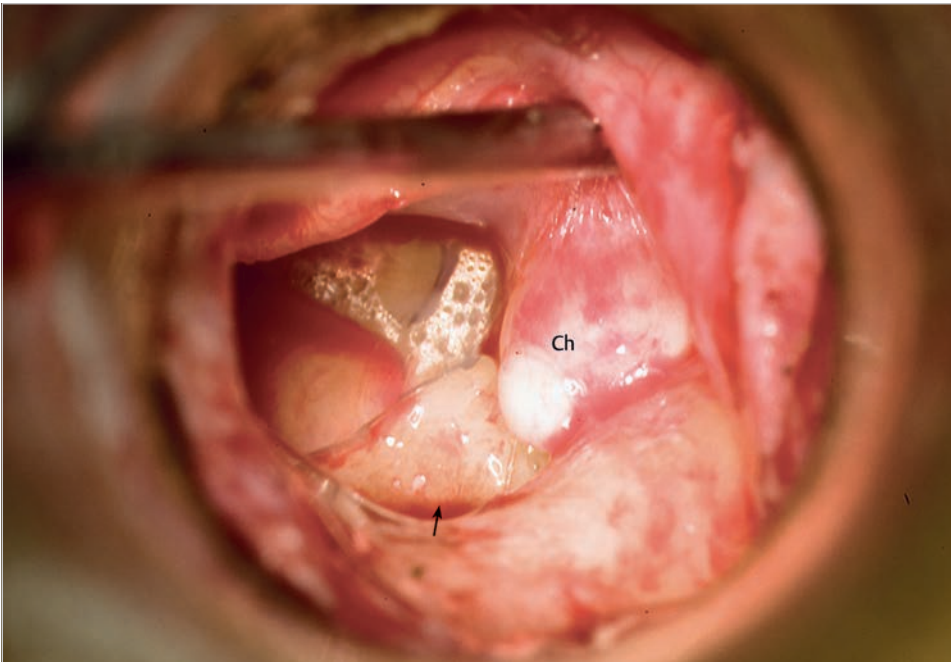


Fig. 7.422 Elevation of the tympanomeatal flap is advanced superiorly to gradually expose the round window niche (*arrow*), the promontory, and the area of the oval window. The procedure exposed residual cholesteatoma covering the stapes. The Silastic sheeting is still present on the medial wall in this moment. Ch, cholesteatoma.

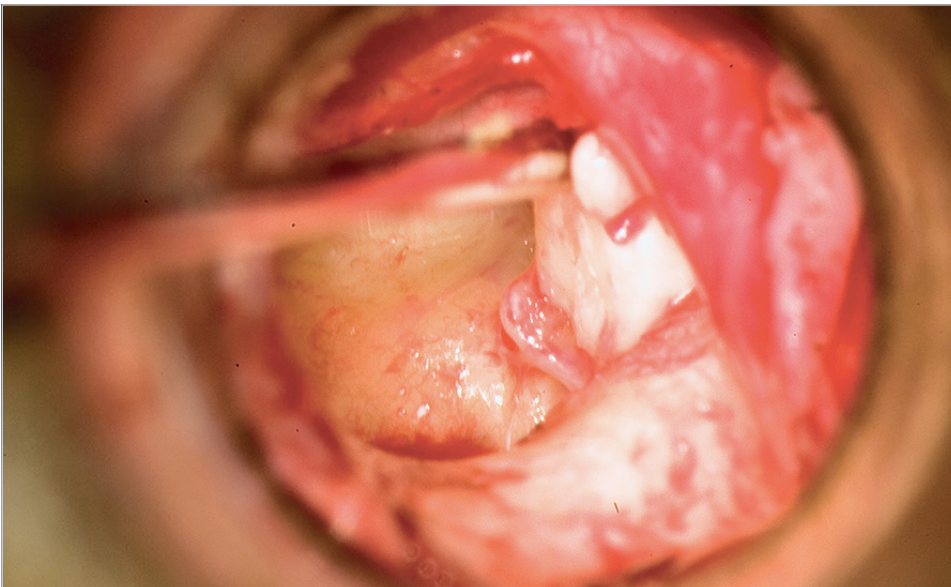


Fig. 7.423 The residual cholesteatoma is carefully dissected. The residual cholesteatoma seems to be originated from the superior face of the superstructure of the stapes.

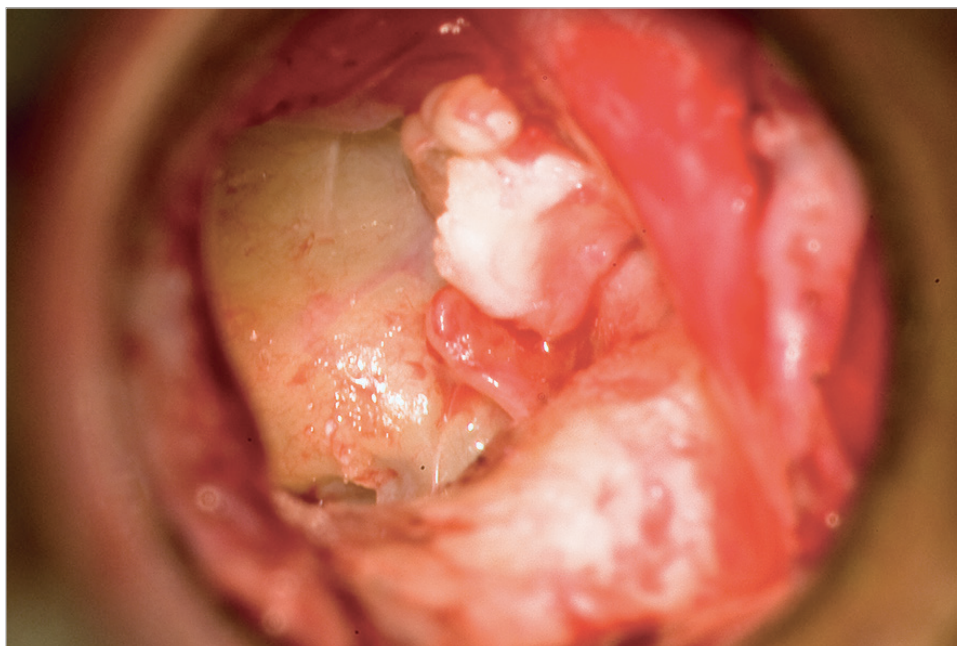


Fig. 7.424 The residual cholesteatoma is dissected from the stapes taking care not to tear the matrix.

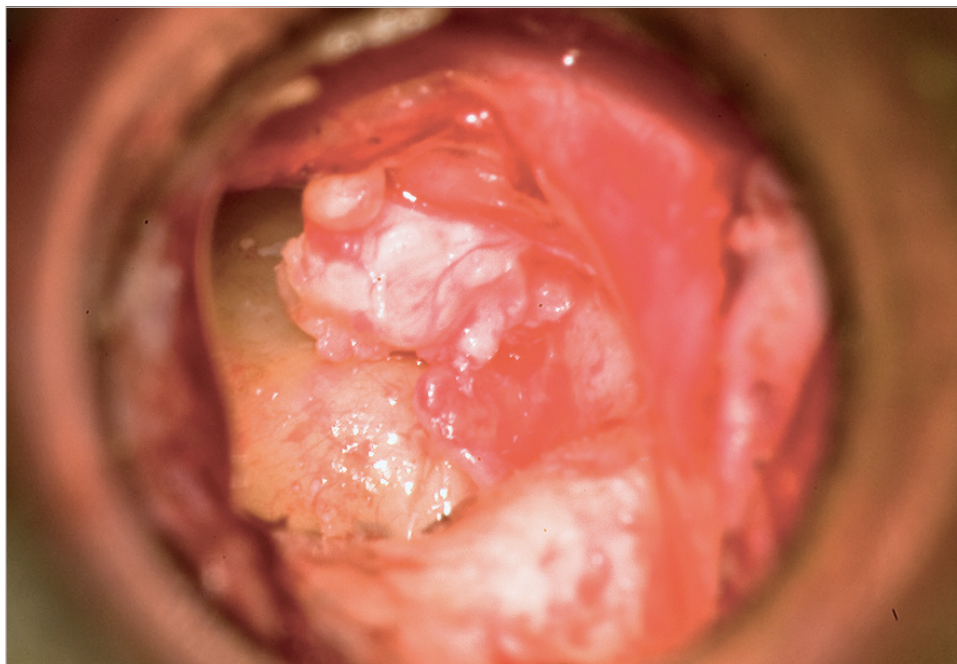


Fig. 7.425 The cholesteatoma is detached from the stapes.

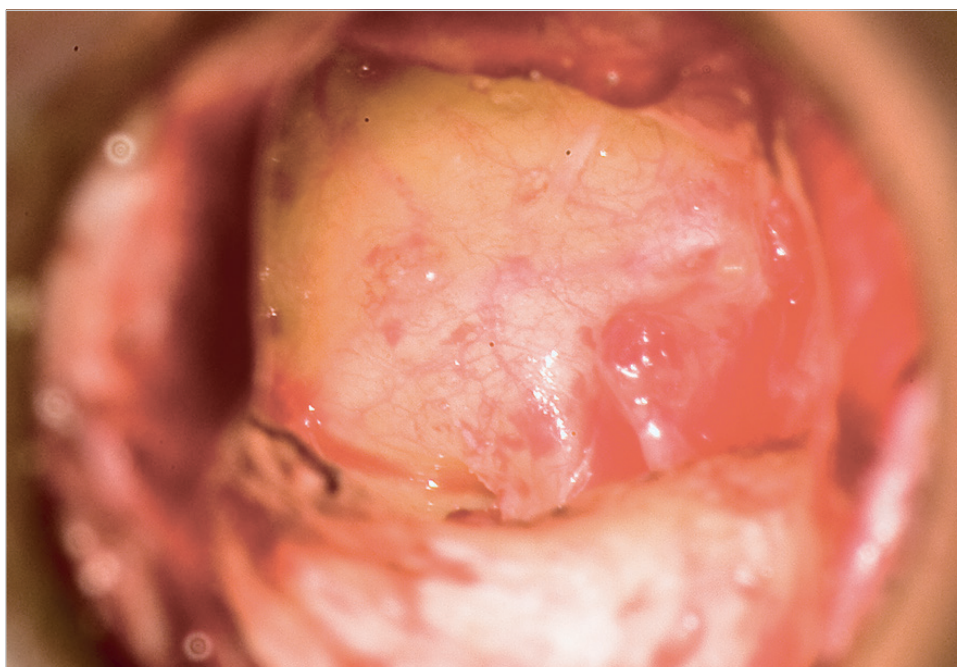


Fig. 7.426 The matrix is completely removed from the middle ear.

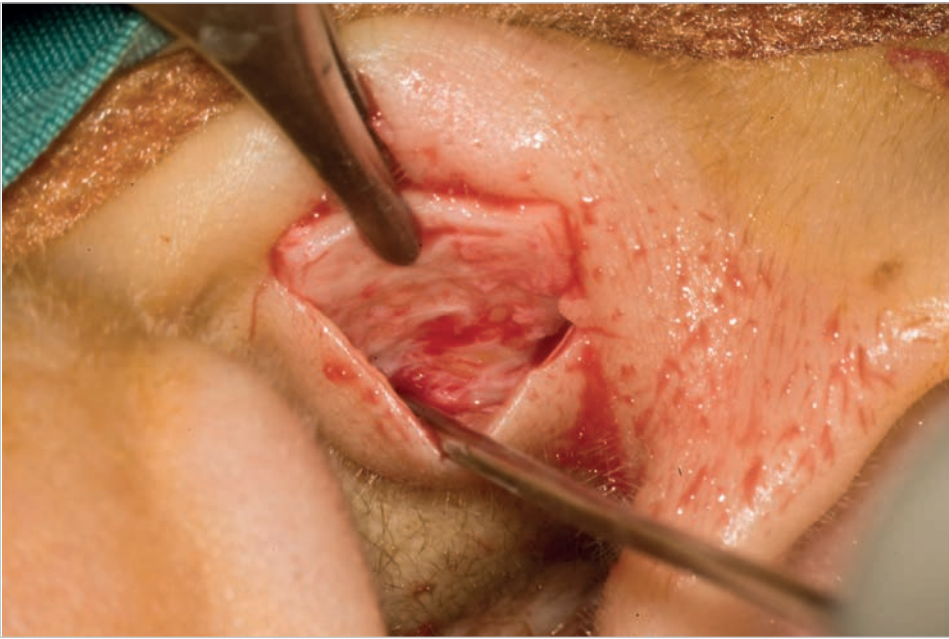


Fig. 7.427 A piece of tragal cartilage is harvested.

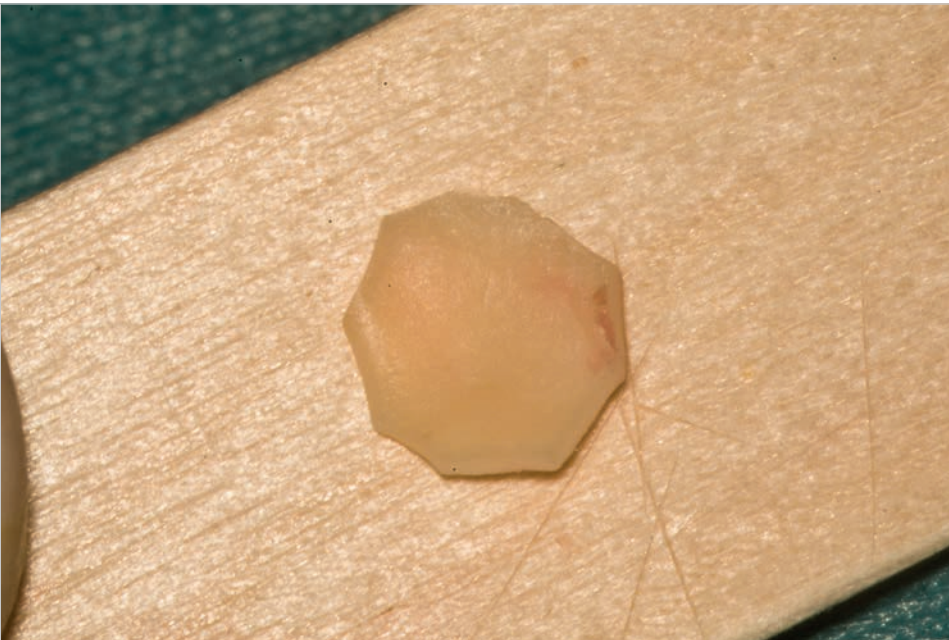


Fig. 7.428 The cartilage is cut to fit to the posterosuperior quadrant of the tympanic membrane.



Fig. 7.429 The tympanic cavity is packed with Gelfoam, leaving the head of the stapes uncovered.

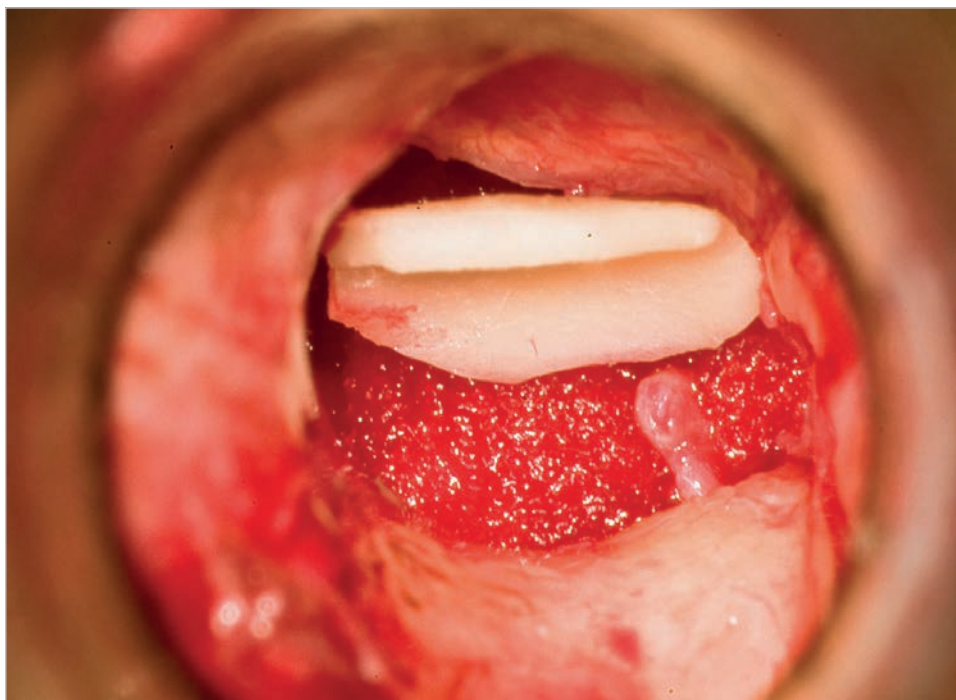


Fig. 7.430 The cartilage is introduced into the tympanic cavity.

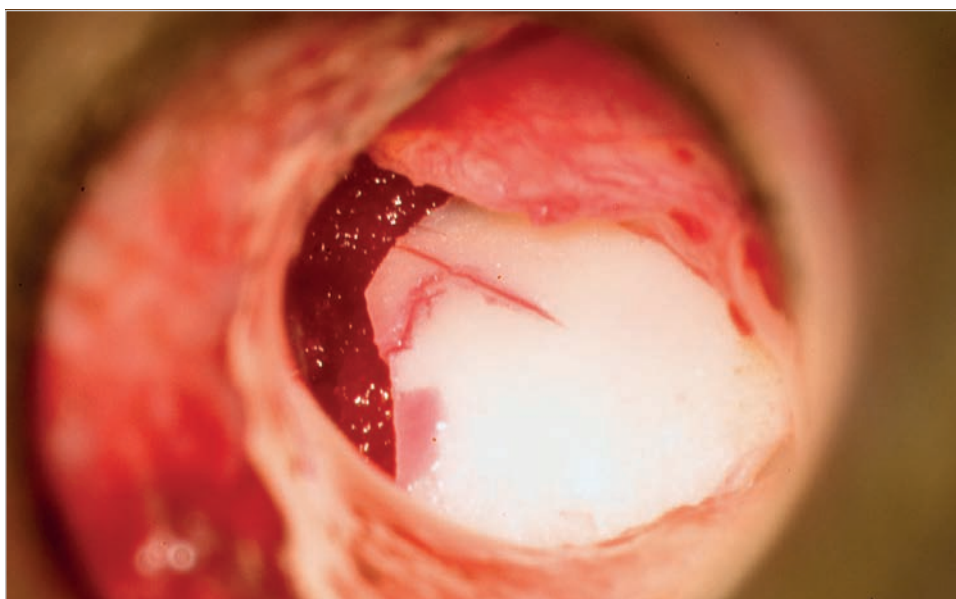


Fig. 7.431 The cartilage is placed over the superstructure. A small contact between the cartilage and the facial ridge does not affect postoperative hearing severely.



Fig. 7.432 The tympanomeatal flap is replaced over the cartilage, and the meatus is further packed with Gelfoam.

Case 7.33 (Left Ear)

See ► Fig. 7.433, ► Fig. 7.434, ► Fig. 7.435, ► Fig. 7.436, ► Fig. 7.437,
► Fig. 7.438, ► Fig. 7.439, ► Fig. 7.440, ► Fig. 7.441.

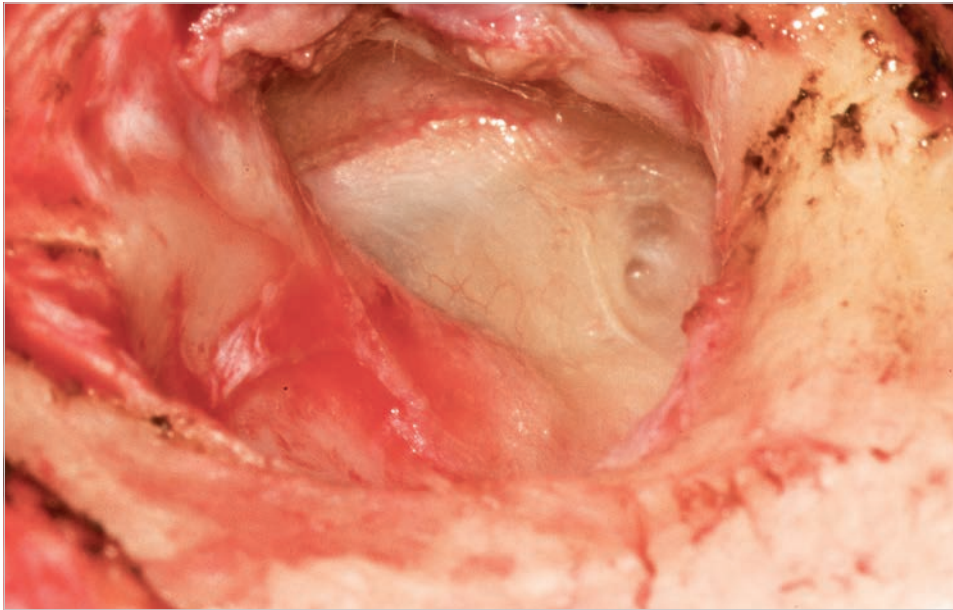


Fig. 7.433 A case of residual cholesteatoma after first-stage canal wall down procedure is shown. Since extensive residual disease is suspected in preoperative radiological examination, access to the tympanic cavity is established through a retroauricular incision.



Fig. 7.434 The skin covering the cavity is dissected toward the tympanic membrane. Note that the cavity is wellrounded in the former surgery. Bleeding from the cavity wall and the skin can be controlled with cottonoid.



Fig. 7.435 The tympanic cavity is entered and Silastic sheeting placed in the firststage is removed. Under the Silastic sheeting, debris covering the medial wall is identified.

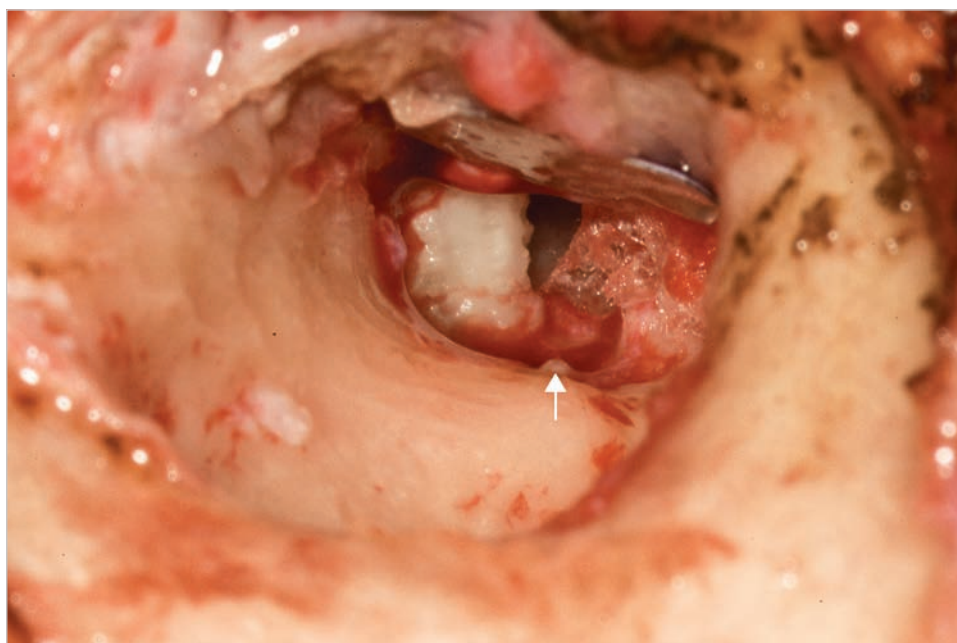


Fig. 7.436 The tympanic cavity is opened widely, and the head of the stapes is identified (*arrow*). The facial ridge is further lowered to visualize the hypotympanum better. After establishing adequate access, debris is carefully moved inferiorly to identify the location of residual disease.

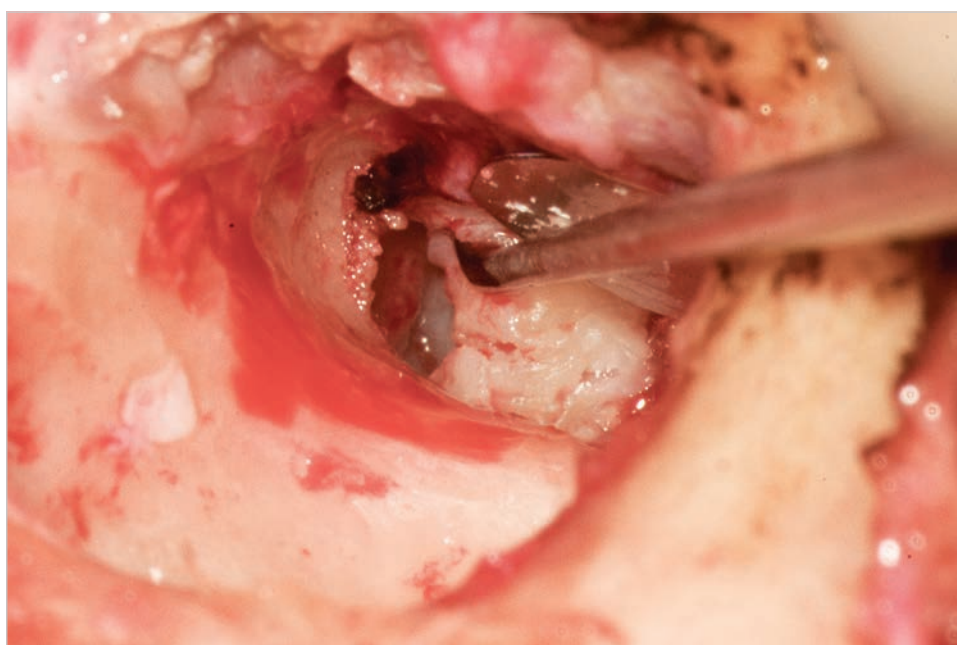


Fig. 7.437 The matrix covering the hypotympanum is carefully dissected from the bony wall. A part of tympanic membrane covered with the matrix should be resected.



Fig. 7.438 The final piece of skin covering the medial face of the bony annulus is seen (*white arrow*). The stapes covered with scar tissue is seen (*yellow arrow*).



Fig. 7.439 Residual cholesteatoma in the tympanic cavity is eradicated. The scar tissue covering the stapes is removed to expose the superstructure (*arrow*).



Fig. 7.440 The tympanic cavity is packed with pieces of Gelfoam. A small piece of Silastic sheeting is placed over it.

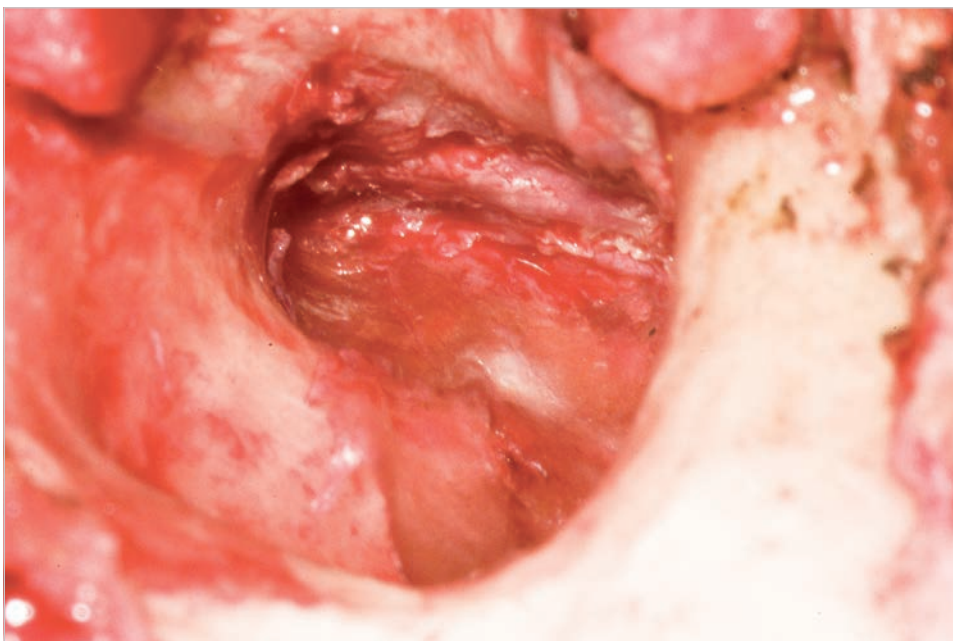


Fig. 7.441 A large piece of temporalis fascia is grafted underlay, and the skin is replaced over it.

7.5 Revision Surgery after Open Technique

Revision surgery is always difficult and dangerous, since the original anatomy may be distorted and some pathological tissue may occupy critical location (► Fig. 7.442). Considerable removal of bony structures increases chance of losing landmarks, and simultaneously, losing protection of delicate structures. This makes *revision in open cavity one of the most difficult middle ear surgeries*, and this surgery should be left to experienced surgeons.

Many problems may be encountered during revision surgery. Healthy arrangement of the skin in the area of tympanic membrane is often disturbed by lateralization, infection, and mucosal substitution. The meatus may be stenotic by either abundant scar tissue or reactive bone formation. The facial nerve may be uncovered in its mastoid segment, and may adhere to the scar tissue in the canal. Occasionally, uncovered important and fragile structures such as the middle fossa dura, the posterior fossa dura, and the sigmoid sinus may be seen in the cavity. The skin covering the dura may be adherent, and distinction between dura and the epidermis may be extremely difficult, even for experienced surgeons. *A preoperative CT scan is very informative and important in revision surgery.*

In the majority of cases, the most important single factor for failed open tympanoplasty is poor execution of surgical technique. Surgical correction comprises execution of appropriate techniques in the right places as described before, making shape of the cavity round and smooth, with the tympanic membrane properly located.

7.5.1 Surgical Steps

1. Postauricular incision is used for the revision mastoidectomy. Either the temporalis fascia or connective tissue is harvested from the incision as the grafting material.
2. Before making incision in the musculoperiosteal flap (or scar tissue covering the cavity), the underlying bone should be palpated carefully to avoid possible injury to the exposed sigmoid sinus and the dura of middle and posterior cranial fossae. The incision of the musculoperiosteal layer should be executed on the underlying bone, to create a quadrangular-shaped flap. The flap is detached from the bone and folded anteriorly. This procedure partially detaches the skin covering the posterior wall of the cavity.
3. The open cavity is entered by incising the detached skin of the posterior wall (from superior to inferior in the right ear). Two self-retaining retractors are applied to hold the auricle together with the triangular musculoperiosteal flap, and to maximally expose the cavity.
4. If there is a recurrent cholesteatoma in the cavity, the matrix of the cholesteatoma is opened with malleable scissors and debris is evacuated with suction. It serves for appropriate visualization of the underlying structures.
5. The cavity is carefully inspected. Location of the important structures such as the ossicular chain, the facial nerve, semicircular canals, the sigmoid sinus, and the middle fossa plate are identified as fast as possible. At the same time, cause of the failure is identified.
6. The tympanic cavity is inspected sometime after the tympanic membrane is fully visualized.

7. If there is persistent inflammation in the cavity, the shape of the cavity needs to be corrected. A prominent mastoid tip, inadequately lowered facial ridge, stenotic meatus, and bony overhangs in edges of the mastoid cavity are common findings in the failed cavity. Incomplete removal of the diseased cells may also be seen in the tegmen, the sinodural angle, the mastoid tip, and retrosigmoid area.
8. If the shape of the cavity is inappropriate, as much skin covering the cavity as required for the correction is carefully elevated medially. Dissection of the skin should be carried out under direct vision. For that sake, bony overhangs on the edge should be drilled first. Dissection of the skin is advanced medially, toward the tympanic membrane taking care not to damage important structures that might be exposed beneath the skin.
9. Any pathological tissue in the cavity such as inflamed skin and granulation should be resected. The skin elevated from the cavity that interferes with drilling may partially be resected. Healthy segment of the resected skin may be trimmed and replaced in the cavity as free skin graft in the end of surgery.
10. Drilling of the operated cavity usually causes more bleeding than the first surgery. *It is important to stop bleeding with a diamond burr and to establish bloodless operating field. Never drill in the bloody cavity.* Even if the cavity is anatomically distorted, constant structures are the middle cranial fossa dura and the sigmoid sinus. As an initial clue of the anatomy, find these structures first during removal of bony overhangs and saucerization (► Fig. 7.443) of the cavity. Remaining skin and the tympanic membrane should be protected from a burr by a piece of aluminum sheet.
11. The bone over the middle cranial fossa is thinned out until the dura is identifiable, taking care not to expose it. During this procedure, care should be taken not to damage dural or meningoencephalic herniation that may protrude from the tegmen.
12. If small area of either the posterior or the middle cranial fossa dura is exposed but not protruded in the cavity, a pedicled subcutaneous tissue flap may be harvested beneath the concha cartilage later during the meatoplasty and placed over that area. Large erosion should be repaired by using cartilage and bone paté (see Chapter 10).
13. The bone over the sigmoid sinus is thinned. Drilling of the sinodural angle is important to obtain a saucerized cavity. Air cells posterior to the sigmoid sinus is also removed.
14. Remaining cells around the antrum are removed to create wide opening of this area. Special attention should be paid in this area since labyrinthine fistula is frequently found in the failed cavity. Most of fistula is located in the lateral semicircular canal. Therefore, it is important to suppose existence of a fistula during removal of pathology or elevation of skin flap from this area. If fistula is present, a small piece of skin is left in place. In case of recurrent cholesteatoma, debulking and sharp dissection of the matrix rather than elevation reduce the risk for accidental opening of the fistula (see Chapter 10).
15. The facial nerve is identified without uncovering it. The two consistent landmarks for identifying facial nerve in the operated cavity are the cochleariform process in the mesotympanum and the digastric ridge in the mastoid tip. The facial nerve runs directly superior to the cochleariform process. The facial nerve runs just anterior to the digastric ridge, coursing perpendicular to it. Other landmarks such as the lateral semicircular canal, the oval window niche, and the body of the incus are also important if they are identifiable. Once the facial nerve is identified, it is very important that the facial ridge over the nerve is lowered all the way to the mastoid tip to make round cavity (► Fig. 7.444, ► Fig. 7.445).

16. The anterior and posterior buttresses are removed. Any bony spur and air cells in the attic are drilled as much as possible. Pathology in the middle ear, if any, is removed.
17. The anterior and the inferior canal walls are calibrated to make shape of the entire cavity round and sufficiently visible from the meatus.
18. If the patient is old and hearing is not serviceable, a radical mastoidectomy is performed. If hearing is worth preserving but the ossicular chain is insulted, the rest of the tympanic membrane is preserved and myringoplasty is performed if required. Ossiculoplasty can be performed in the same stage or the second stage, depending on the nature of the

failure and condition of the middle ear. If the ossicular chain is intact and the tympanic cavity is free of disease, modified Bondy technique is applied.

19. In rare cases, extensive pneumatization and large dips in the cavity are filled with cartilage and/or bone paté. The cavity is covered as wide as possible with the temporalis fascia.
20. In highly pneumatized mastoid, posteriorly pedicled subcutaneous periosteal flap might be required to obliterate the area of the mastoid tip.
21. For satisfactory result, it is very important to conduct meatoplasty correctly in accordance with the size of the cavity (see Meatoplasty earlier in this chapter).



Fig. 7.442 A case of stapes disarticulation found in revision cholesteatoma surgery is seen. The footplate of the stapes is disarticulated from the oval window, and the anterior end of the footplate is clearly identified (*arrow*). Pulling out of this stapes with inattentive maneuver may cause a dead ear. The situation can be identified with careful interpretation of preoperative CT.

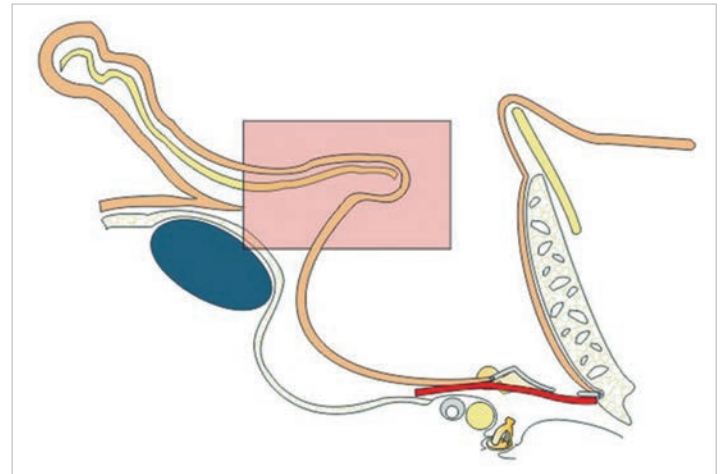


Fig. 7.443 All bony overhangs should be drilled.

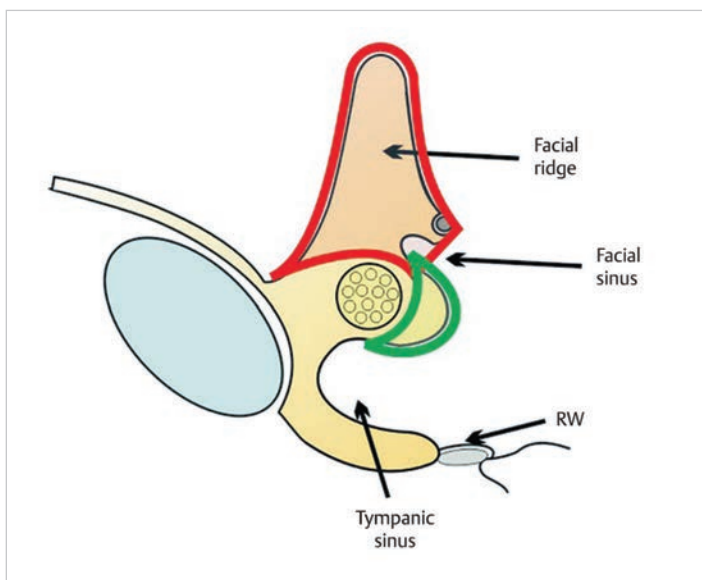


Fig. 7.444 A high facial ridge should be lowered. RW, round window.

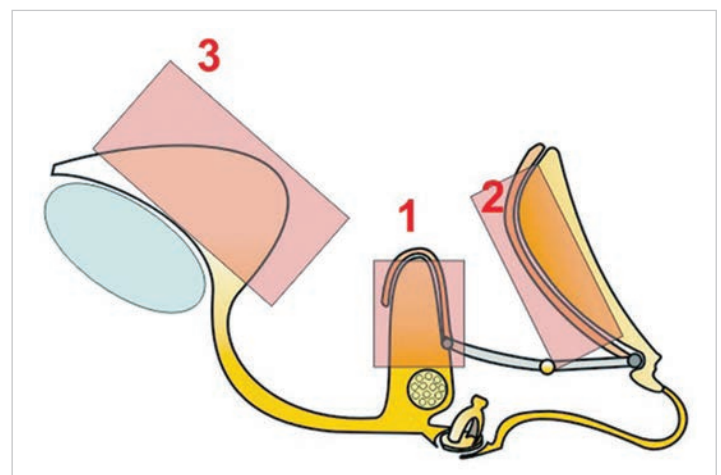


Fig. 7.445 Common causes of failure: (1) high facial ridge; (2) stenotic meatus; (3) bony overhangs.

Case 7.34 (Right Ear)

See ▶ Fig. 7.446, ▶ Fig. 7.447, ▶ Fig. 7.448, ▶ Fig. 7.449, ▶ Fig. 7.450, ▶ Fig. 7.451, ▶ Fig. 7.452, ▶ Fig. 7.453, ▶ Fig. 7.454, ▶ Fig. 7.455, ▶ Fig. 7.456, ▶ Fig. 7.457, ▶ Fig. 7.458, ▶ Fig. 7.459.

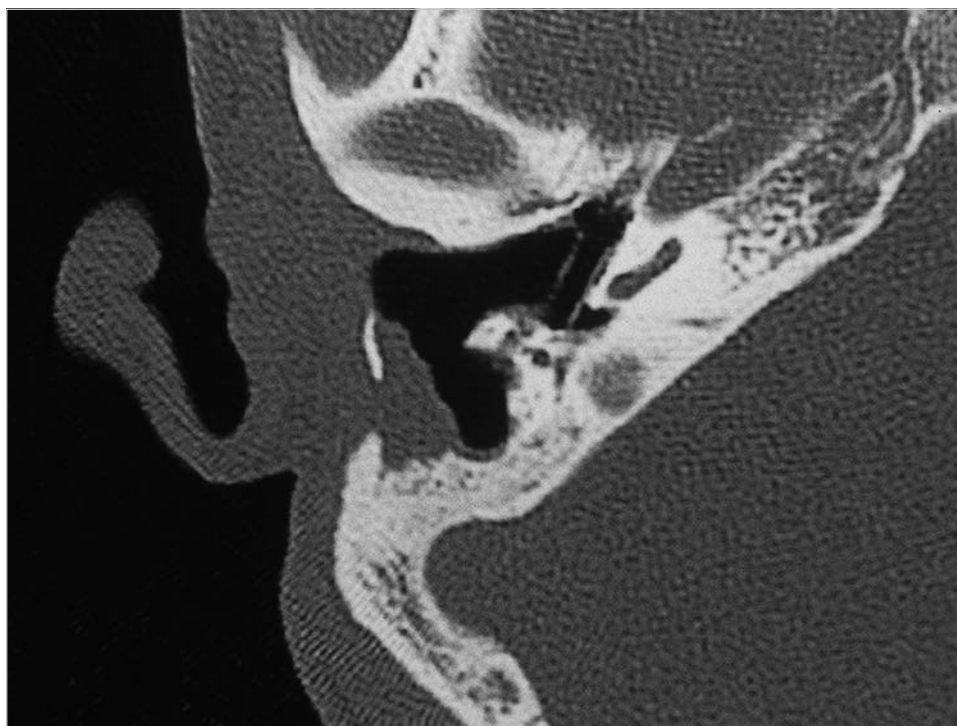


Fig. 7.446 The patient was operated elsewhere, and inflammation of the canal wall down cavity sustained after the surgery. The CT image shows an axial view of the badly performed canal wall down technique with very high facial ridge, and sharp bony overhangs. A Silastic sheeting is seen in the tympanic cavity.

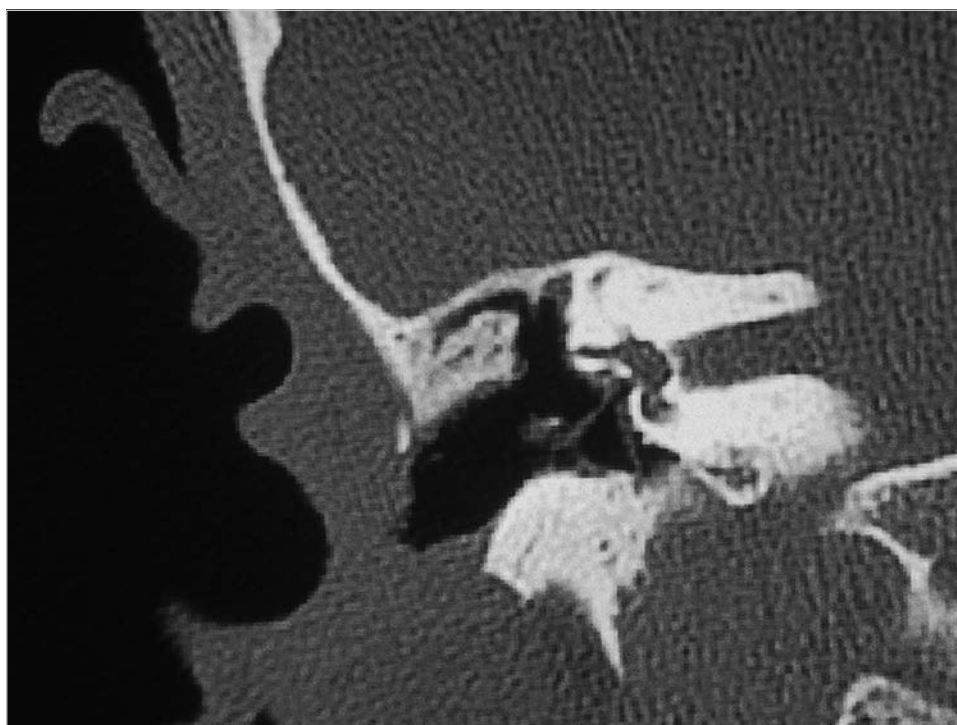


Fig. 7.447 A coronal view shows massive bone left over the middle fossa plate, laterally to the attic. This bony overhang makes impossible to reach area superiorly in the cavity. A large air cell tract opens to this deep dip.

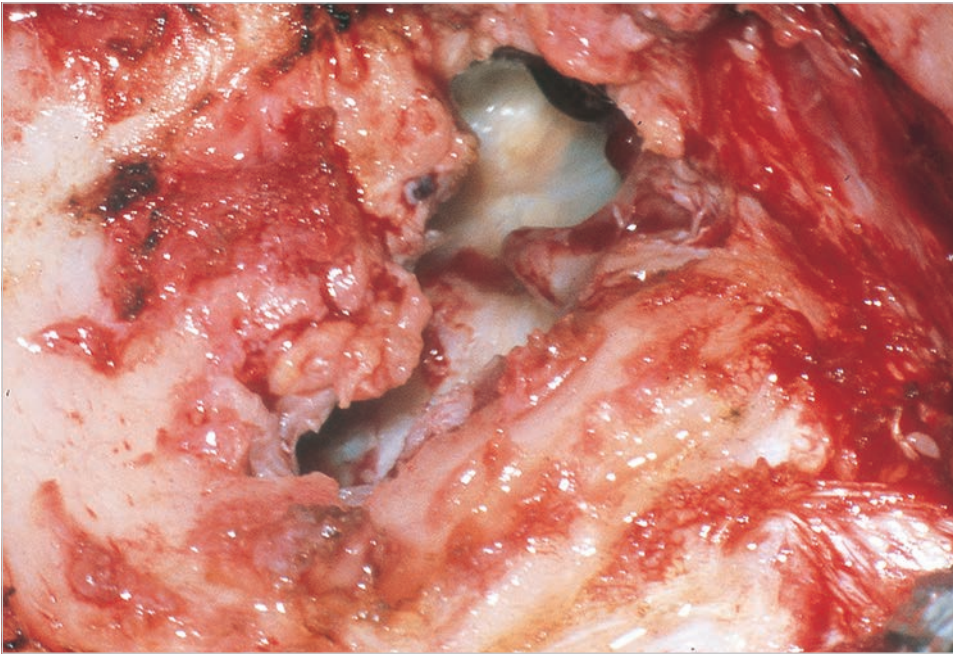


Fig. 7.448 Via retroauricular incision, the cavity is entered. Bony overhangs narrow access to the middle ear.

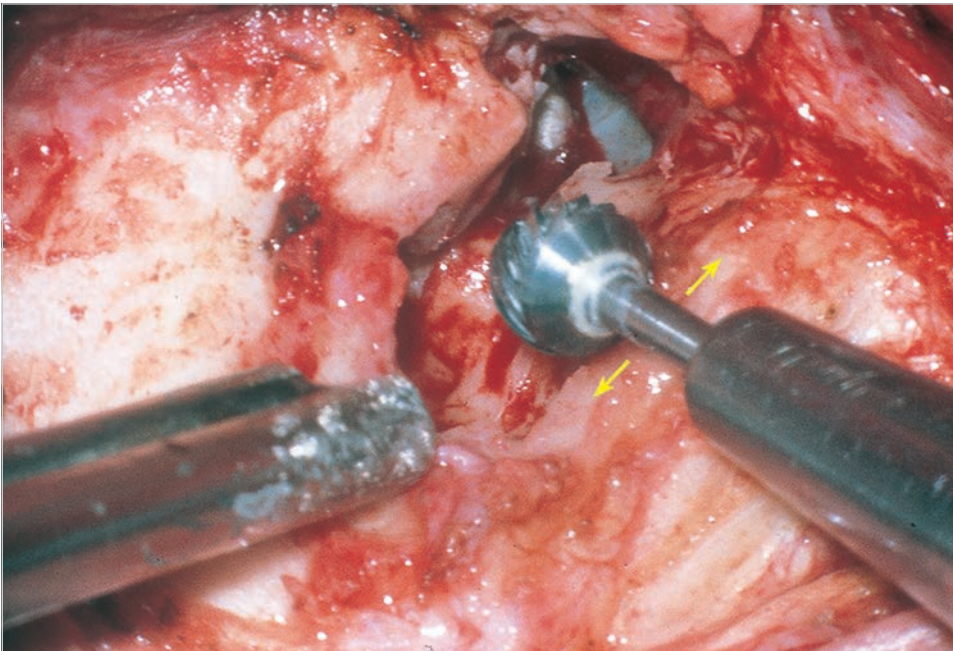


Fig. 7.449 Drilling is started from removal of the overhanging edges, to enlarge access to the cavity. In this area, drill should be moved parallel to the sigmoid sinus.

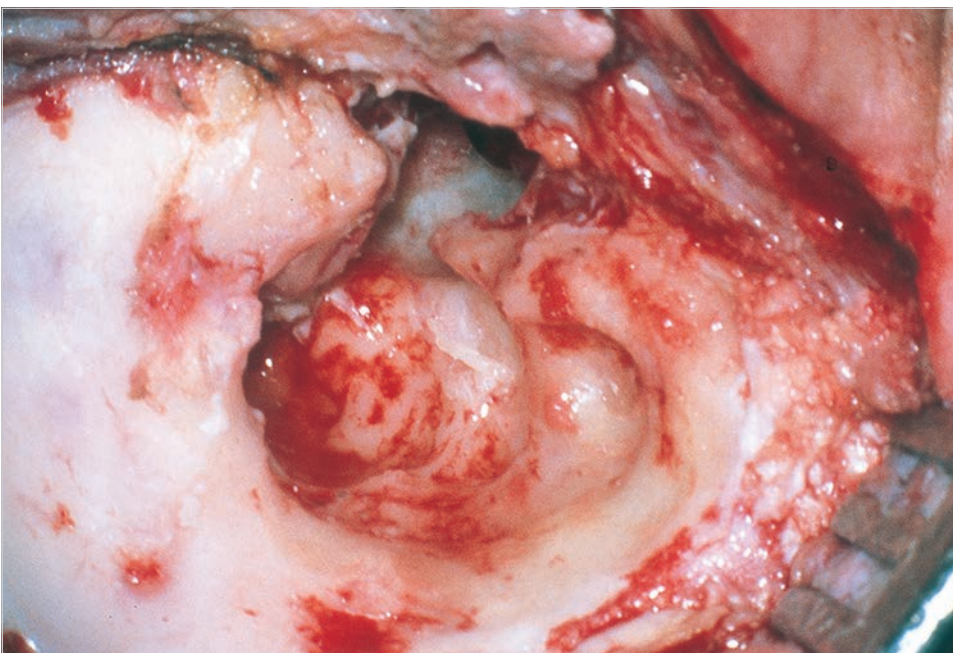


Fig. 7.450 The edges are partially drilled and inflamed skin covering the cavity is removed. It is very important to advance drilling gradually toward the tympanic cavity, with complete visualization of the area to be drilled.

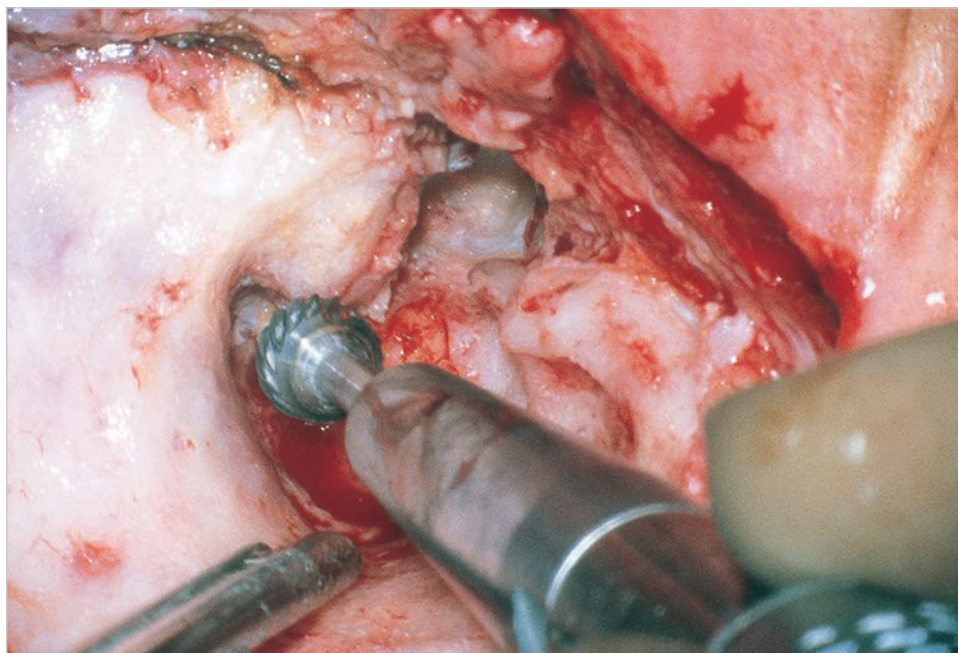


Fig. 7.451 A massive bone shown on the coronal CT (► **Fig. 7.447**) is now removed with a large cutting burr.

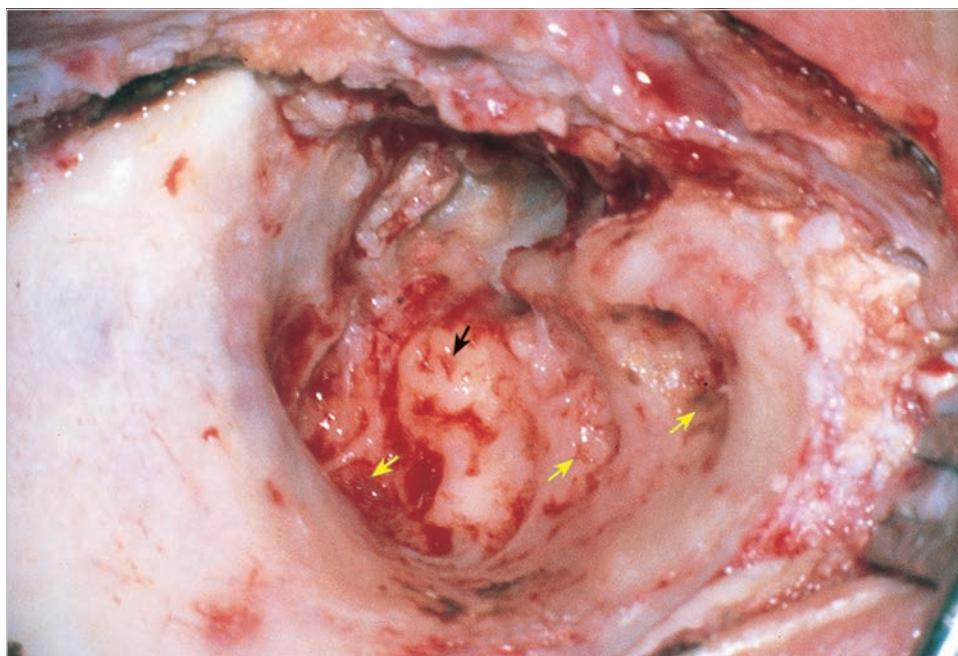


Fig. 7.452 The bone is removed and the middle fossa plate is thinned. Large undrilled dips are seen in the area of the mastoid tip and the sinodural angle (*yellow arrows*). The lateral semicircular canal is seen (*black arrow*).

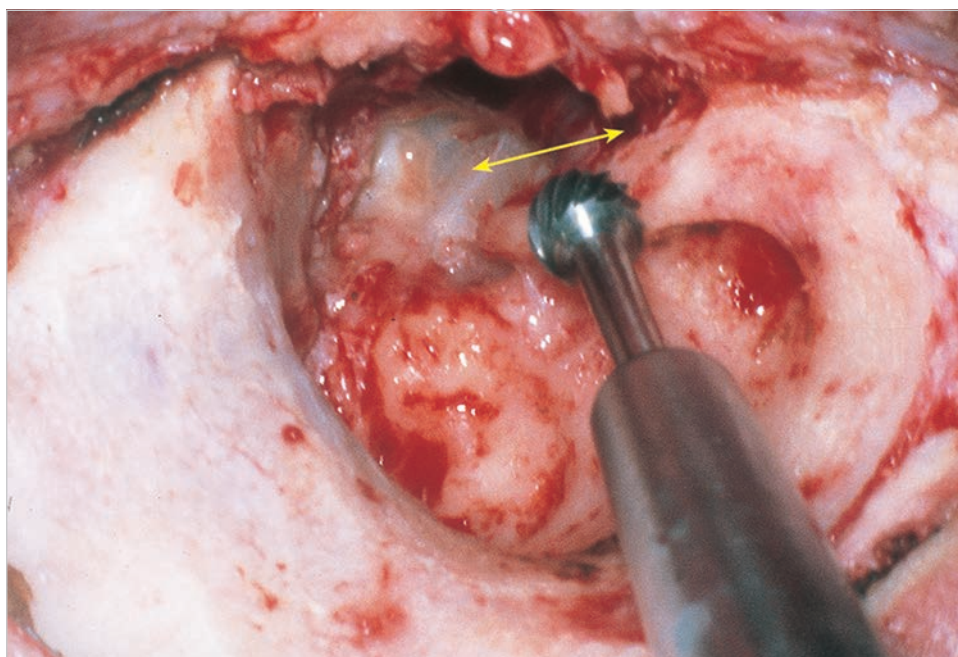


Fig. 7.453 The facial ridge is lowered with a cutting burr. The burr should be moved parallel to the nerve.

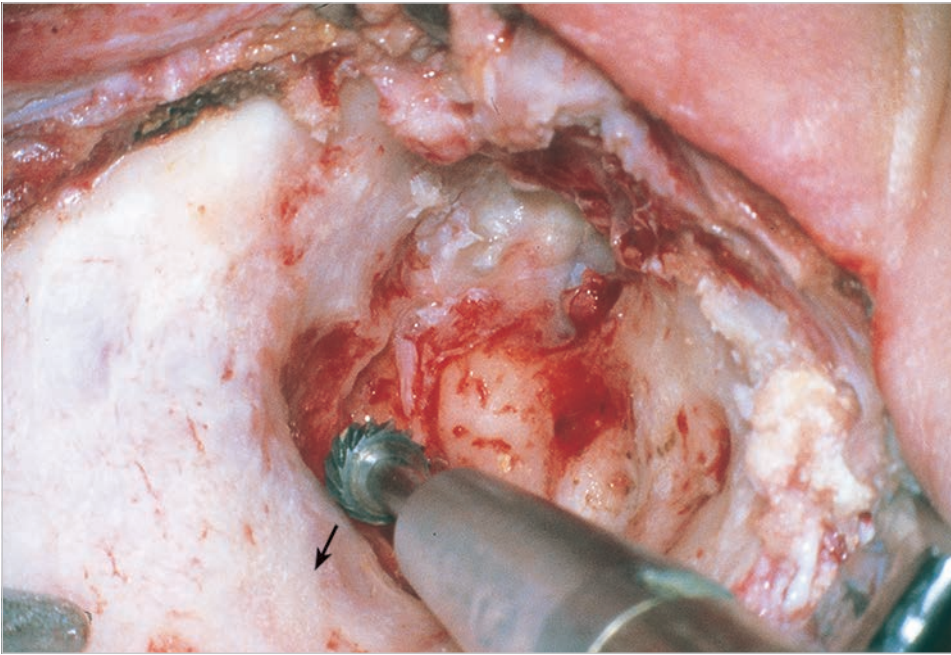


Fig. 7.454 The facial ridge is lowered. The sinodural angle is opened with the cutting burr moved medial to lateral.

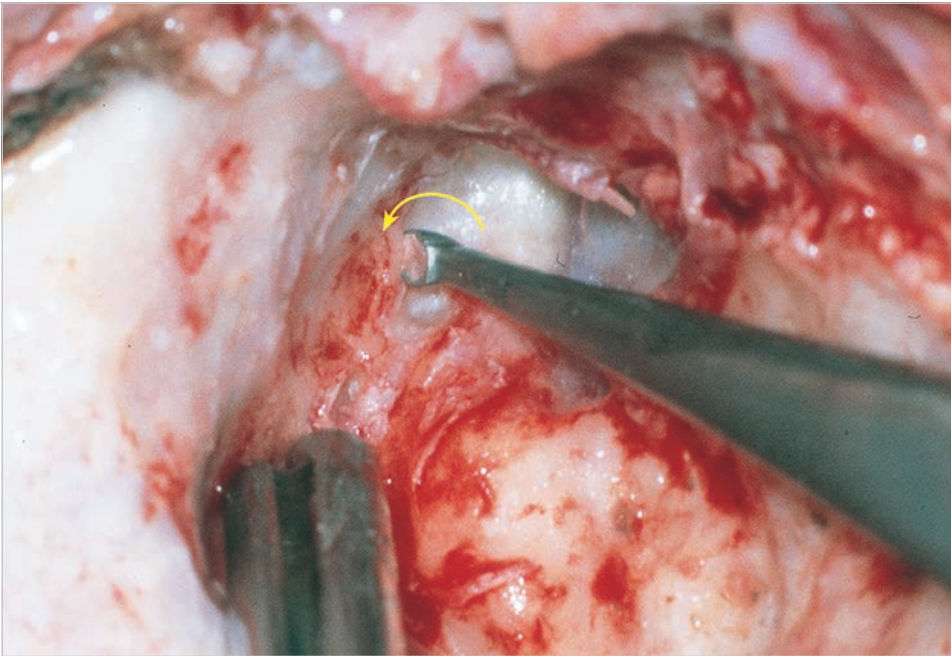


Fig. 7.455 Shape of the cavity is further rounded by removing acute bony protrusions from the tegmen. The curette should be used in rotatory fashion. Otherwise, it may damage the middle fossa dura.

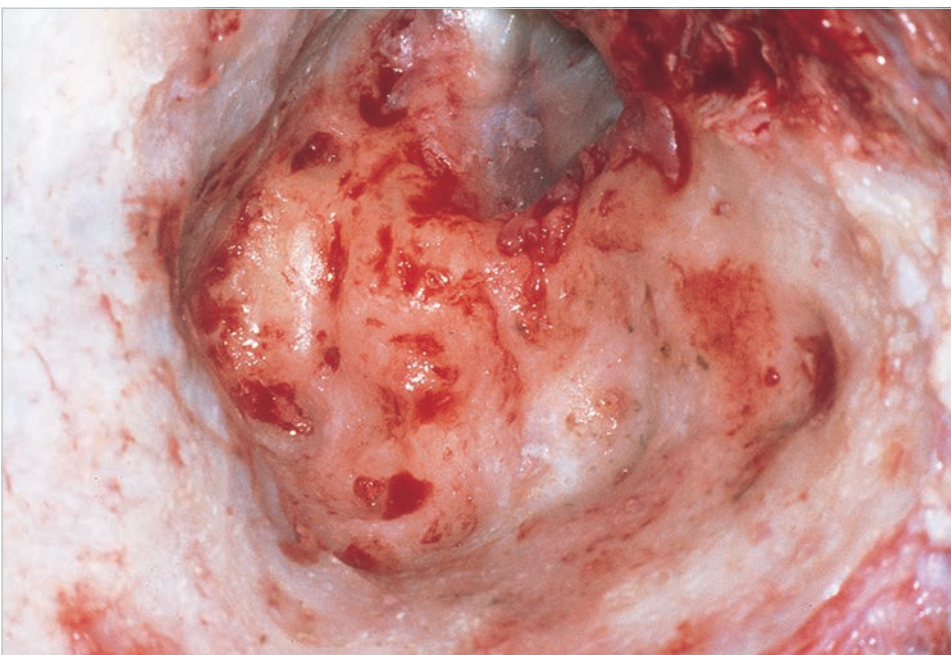


Fig. 7.456 The shape of the cavity after correction is seen. The facial ridge is lowered, the middle fossa plate is thinned, and large dips in the mastoid tip are drilled and flattened. The sinodural angle is opened widely.

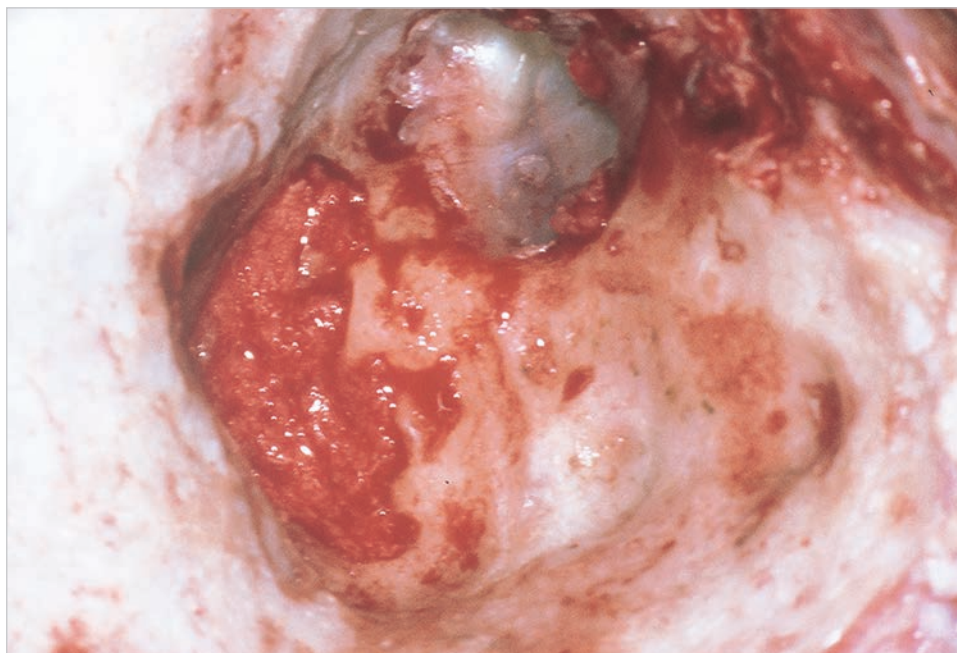


Fig. 7.457 Shallow dips in the supralabyrinthine area are obliterated with bone pâté.



Fig. 7.458 The area bone pâté is applied should be covered with a piece of temporalis fascia. The other piece is placed on the bony wall to cover the exposed bone as much as possible.

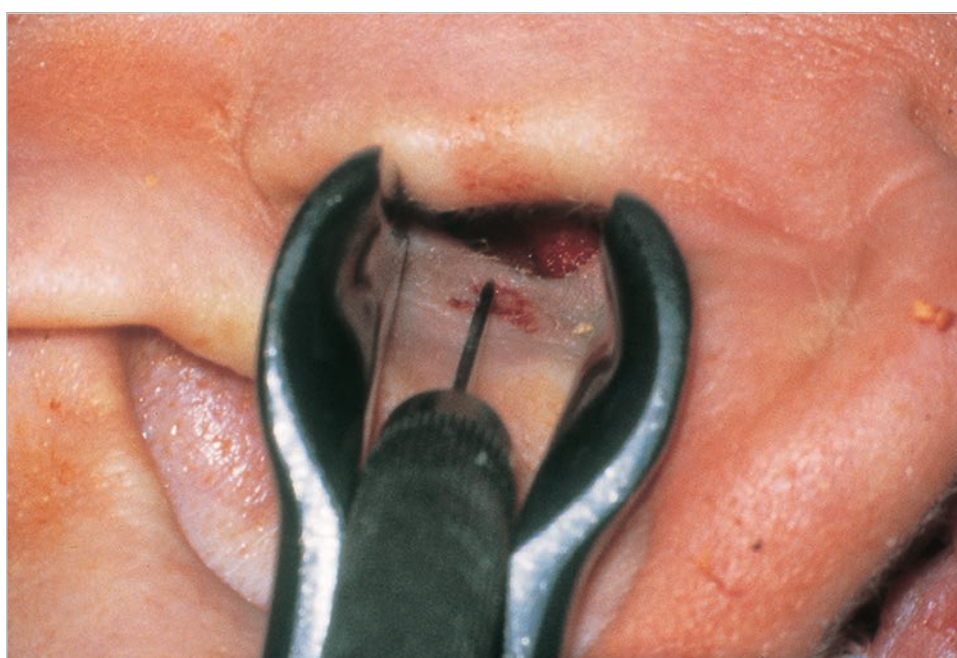


Fig. 7.459 Meatoplasty is conducted to obtain a self-cleansing, easy-to-follow cavity postoperatively.

7.5.2 Hints and Pitfalls of Revision Surgery

- Revision surgery for draining cavity reaches near 30% of the cases operated in our group.
- Postoperative cavity problems are not caused by the CWD technique itself but by insufficient experience of the surgeon.
- Cause of failure frequently seen in revision surgery for draining cavities is incorrect execution of CWD technique with insufficient meatoplasty.
- Beginners should not operate on the ears in which revision surgery is already conducted. This is extremely dangerous because all the anatomy might be altered.
- Very important and fragile structures may be uncovered in the previous surgery. Preoperative high-resolution computed tomography with bone condition is essential. This examination informs you of detailed data on possible dangers you may face.
- In revision surgery, positive identification of the facial nerve is the first objective.
- Eliminate all the bony overhangs and acute ridges covering the middle fossa plate and the sigmoid sinus plate.
- Enlarge the sinodural angle.
- Lower the facial ridge.
- Eliminate the anterior and the posterior buttresses.
- Insufficient removal of the mastoid and perilyabyrinthine cells causes inadequate saucerization, and results in cavity problem.
- Perform meatoplasty if the meatus is not enlarged in the previous surgery. Do not forget it.

Videos

See Video 7.1, Video 7.2, Video 7.3, Video 7.4.

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8 Congenital Cholesteatoma of the Middle Ear

Congenital cholesteatoma is defined as an epidermoid cyst that develops behind an intact tympanic membrane in a patient with no history of otorrhea, trauma, or previous ear surgery. Michaels studied fetal temporal bones and demonstrated the presence of an epidermoid structure between 10 and 33 weeks of gestation. This structure tends to involute spontaneously until it completely disappears. Michaels hypothesized that the persistence of this structure could act as anlage and lead to congenital cholesteatoma. The fact that the most classic location of congenital cholesteatoma, namely in the anterosuperior part of the tympanum, corresponds to the site of the fetal Michaels structure supports this theory. In our cases, however, and contrary to the few studies reported in literature (Derlacki and Clemis 1965, Friedberg 1994, Levenson et al 1986, Cohen 1987), the most common site of congenital cholesteatoma was the posterior mesotympanum. To clearly describe the location of congenital cholesteatomas, we introduced a classification designating mesotympanic localization type A. The type A is subclassified into two: anterior localization type A1 (► Fig. 8.1), and posterior localization type A2 (► Fig. 8.2). Congenital cholesteatomas localized in the attic are classified as type B (► Fig. 8.3). If the cholesteatoma

occupies both the mesotympanum and the attic, it is classified as type A/B (► Fig. 8.4). According to our experience out of 44 cases, half of congenital cholesteatomas arise from the retromalleolar area, and premalleolar localization is uncommon (► Table 8.1). As no existing theory can truly explain the origin of congenital cholesteatoma in the posterior location, a strong conjecture can be made that these lesions might represent a different entity from those of the anterior location that may arise from residue of transiently formed epidermis in fetal period.

Diagnosis is either occasional in the asymptomatic patient, or the patient may complain of hearing loss, or checked in the hearing examination in childhood due to erosion of the ossicular chain. On the other hand, hearing disturbance may be minimal in some cases due to sound transmission through cholesteatoma. In childhood, patients usually do not complain or even aware of hearing disturbance. Recurrent attacks of either acute or secretory otitis media caused by its presence may take the patient to the outpatient clinic, giving chance to be diagnosed. A high degree of suspicion and thorough examination are essential in detecting the presence of these lesions. Anterosuperior cholesteatoma tends to be found in earlier

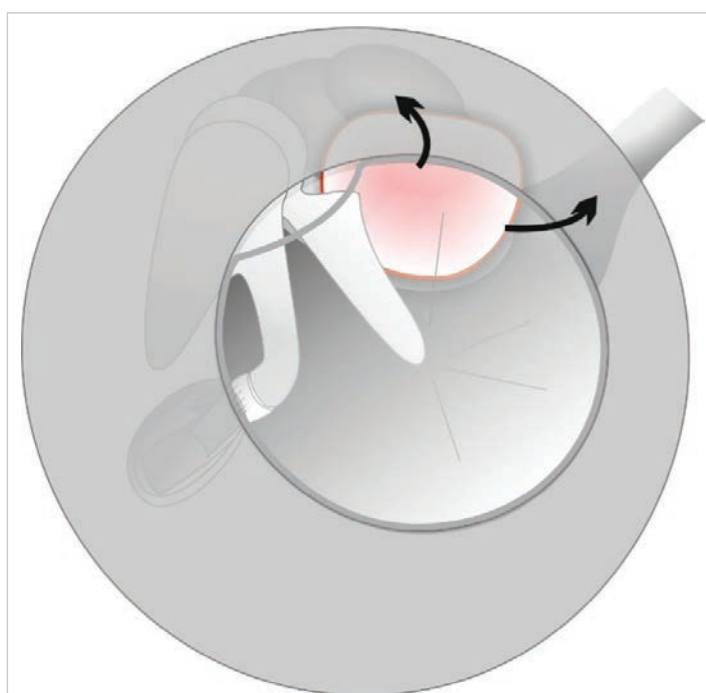


Fig. 8.1 Type A1 congenital cholesteatoma localized in the premalleolar mesotympanum.

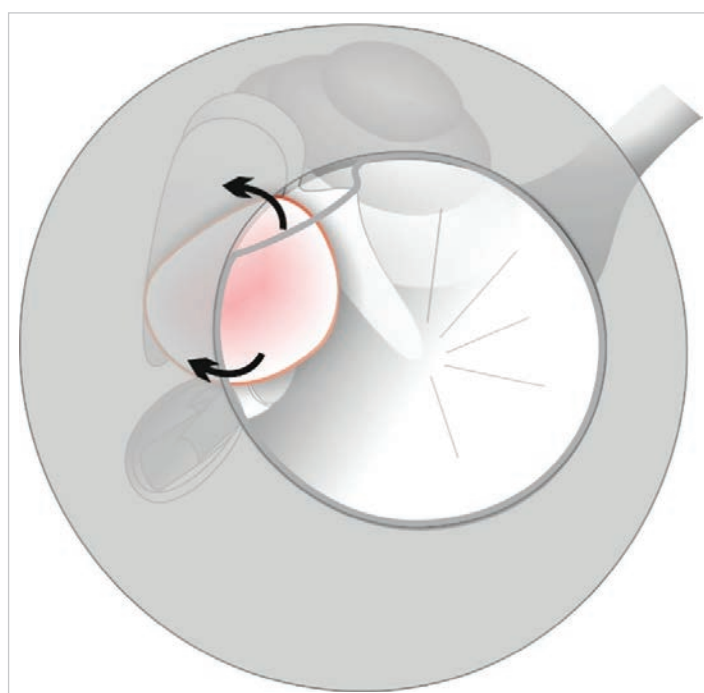


Fig. 8.2 Type A2 congenital cholesteatoma localized in retromalleolar mesotympanum.

infancy under otoscopic examination, but diagnosis of postero-superior cholesteatomas tends to be delayed, until screening of hearing. A high-resolution computed tomography (CT) usually reveals either a round-shaped soft tissue density, or a soft tissue filling the middle ear with disrupted ossicular chain. However, in limited cases of open-type cholesteatoma, a disrupted ossicular chain together with scanty thickening of soft tissue around the oval window may be the only finding in radiology, and differential diagnosis from congenital ossicular chain anomaly is difficult (Kim). Cholesteatoma matrix covered with small amount of debris is verified during surgery.

Basic strategy of surgery for congenital cholesteatoma is the same as acquired ones. In case of child, preservation of the posterior wall should be tried as much as possible. Anterosuperior cholesteatoma can be removed with retroauricular transcanal approach with preservation of the ossicular chain. The incus, then the head of the malleus should be removed if there is a risk of leaving matrix behind. In limited cases of small postero-superior cholesteatoma, removal can be carried out through transcanal approach. However, the majority of posterosuperior cholesteatomas and advanced cholesteatomas require canal wall up mastoidectomy to explore the mastoid, the facial recess, and the medial wall of the attic. Even when the mastoid seems normal in radiologic examinations, open-type cholesteatoma may reach the antrum. Sufficient, but not excessive

thinning of the posterior meatal wall and large posterior tympanotomy play key role in large cases. Reconstruction of the ossicular chain is carried out either in the same stage or in the second stage depending on the status of mucosa and possibility of residual. If there is any risk of residual disease, staging strategy is applied. In very limited cases of advanced cholesteatoma, application of canal wall down technique is mandatory. Since the disease can be bilateral, or might be complicated with contralateral middle ear anomaly, or deafness, it is also important to check contralateral hearing before surgery using objective hearing test such as the auditory brainstem response (ABR), when pure-tone audiometry is not possible. In cases with possible contralateral hearing loss, there is one-stage surgery with ossicular chain reconstruction.

Table 8.1 Localization of congenital cholesteatoma of the middle ear (our experience)		
Type	Location	%
Type A	Mesotympanum	52
• A1	Premalleolar	5
• A2	Retromalleolar	47
Type B	Attic	7
Type A/B	Mixed	41

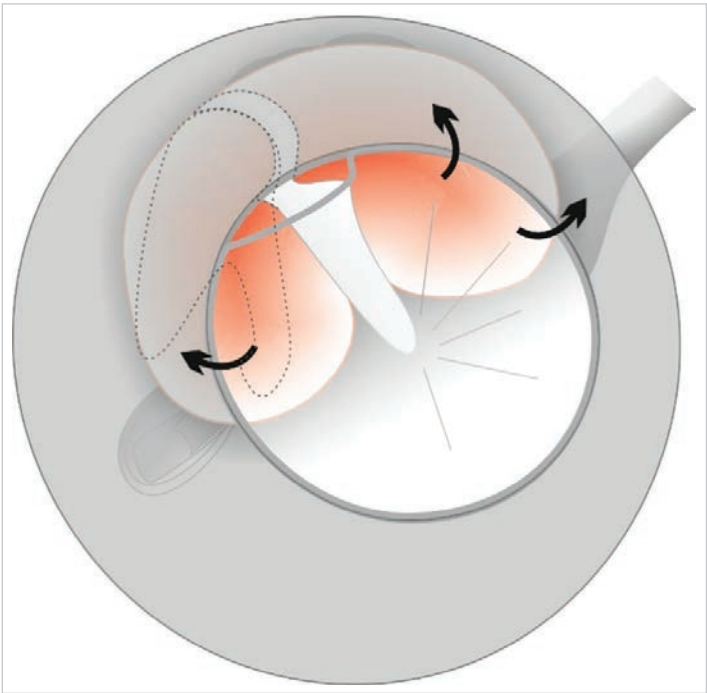


Fig. 8.3 Type B congenital cholesteatoma localized in the attic.

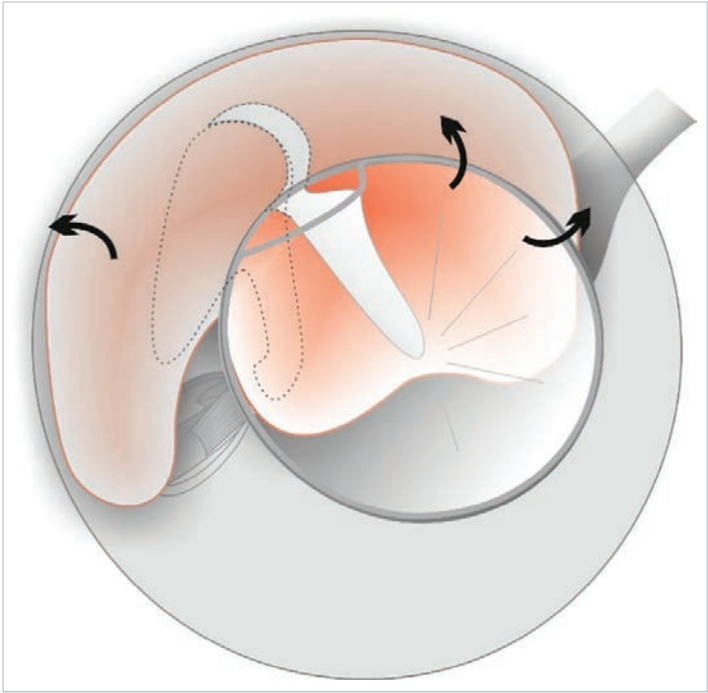


Fig. 8.4 Type A/B congenital cholesteatoma presents in both the mesotympanum and the attic.

Case 8.1 (Right Ear)

See ▶ Fig. 8.5, ▶ Fig. 8.6, ▶ Fig. 8.7, ▶ Fig. 8.8, ▶ Fig. 8.9, ▶ Fig. 8.10, ▶ Fig. 8.11, ▶ Fig. 8.12, ▶ Fig. 8.13.

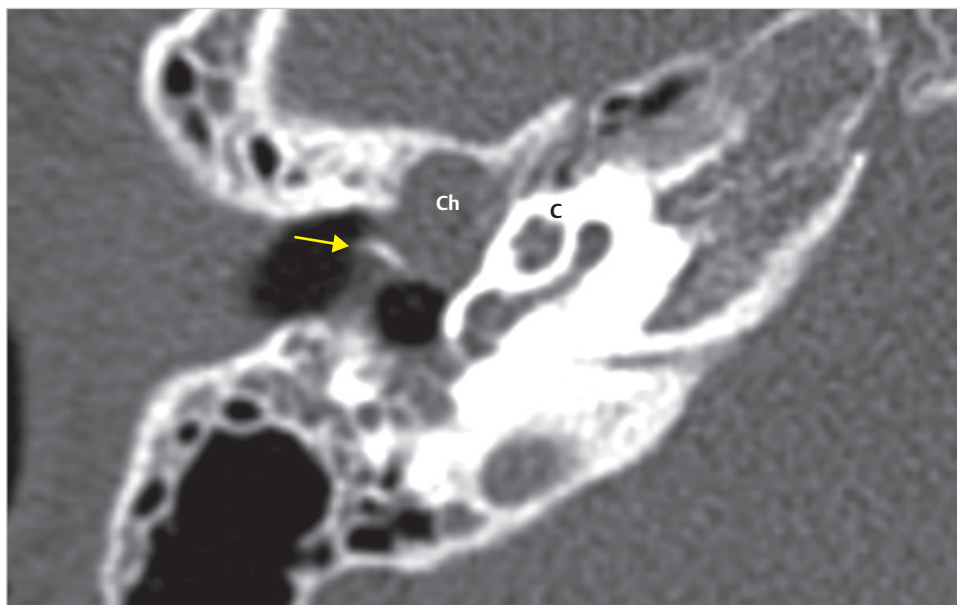


Fig. 8.5 The axial CT demonstrates a round-shaped soft tissue anteriorly to the handle of the malleus (*arrow*) eroding the superior wall of the eustachian tube. The posterior half of the tympanic cavity is free of disease. C, cochlea; Ch, cholesteatoma.

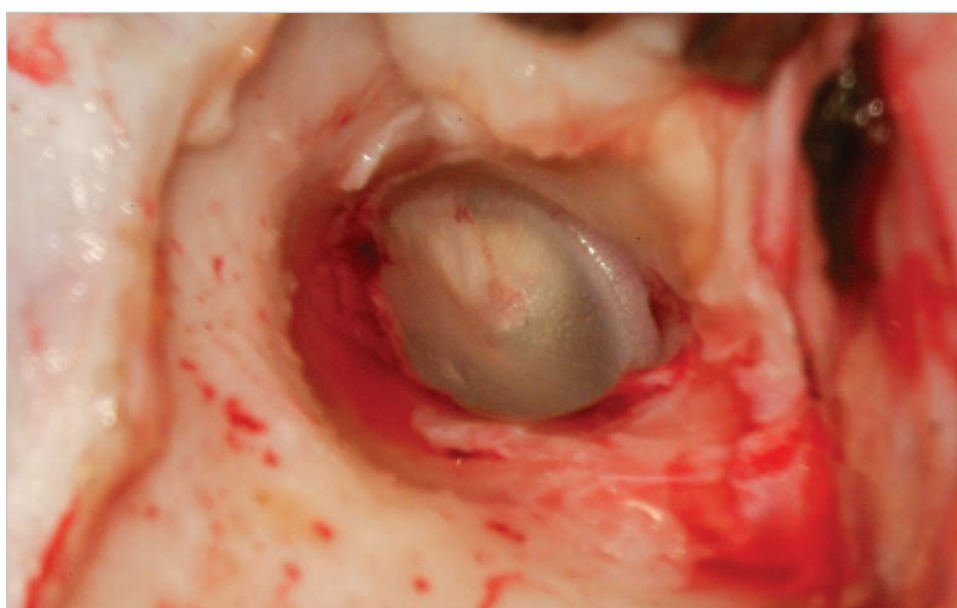


Fig. 8.6 The external auditory canal is opened through retroauricular incision. A whitish mass in the anterosuperior quadrant is identified through the transparent tympanic membrane.



Fig. 8.7 The tympanic membrane is detached from the superior part of the bony annulus, and the handle of the malleus. Congenital cholesteatoma located anteriorly to the handle is started to be visualized. Absence of the matrix anterolaterally designates the cholesteatoma “open-type.”

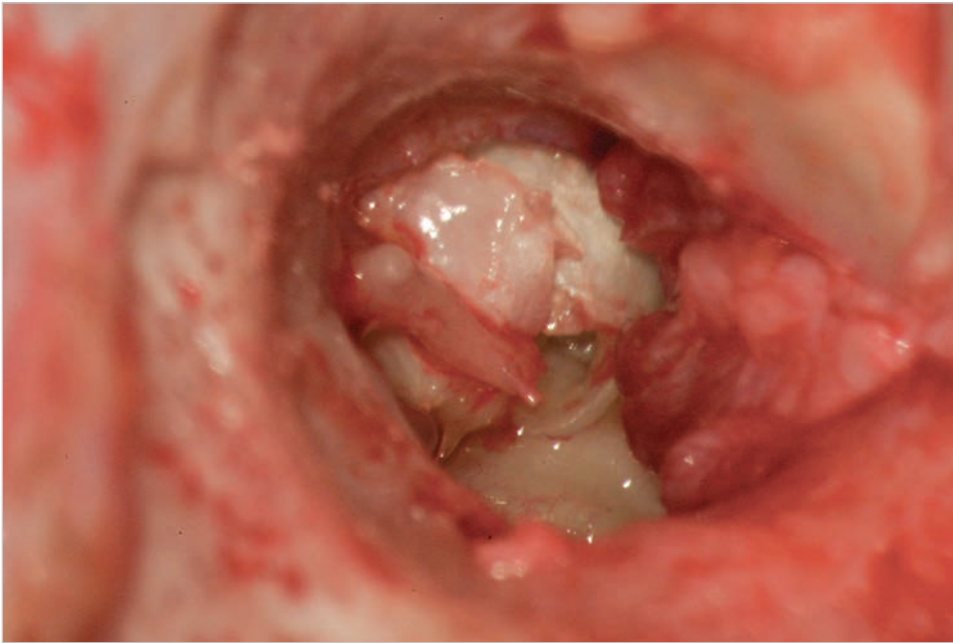


Fig. 8.8 To control inferior pole of the matrix, the tympanic membrane is freed from the handle of the malleus. Sharp dissection is needed in this dissection. The cholesteatoma reaching the eustachian tube is seen.

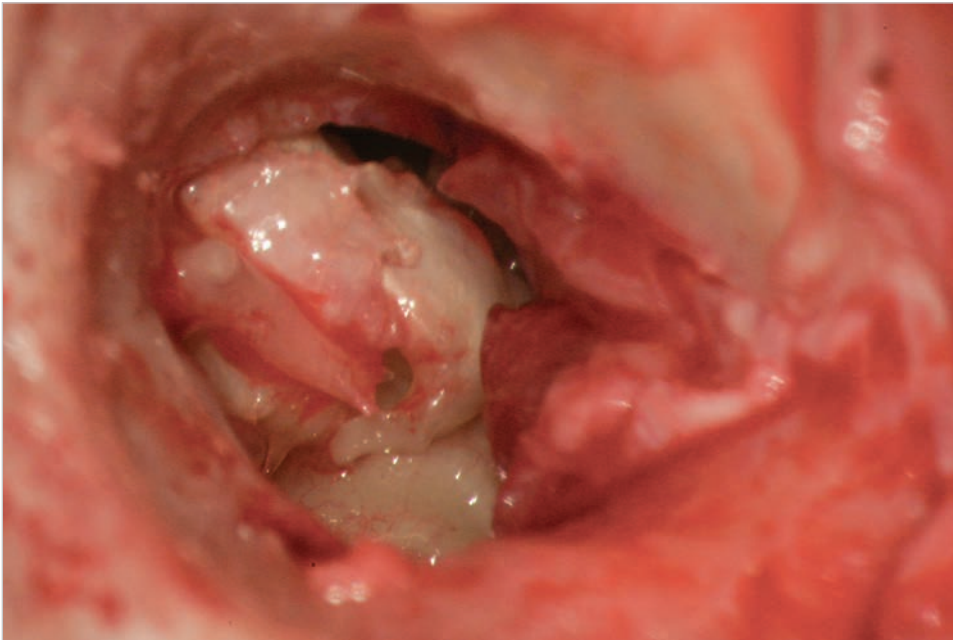


Fig. 8.9 The anterior pole of the cholesteatoma is under control. Since matrix is absent in this area, the bony annulus is left untouched.

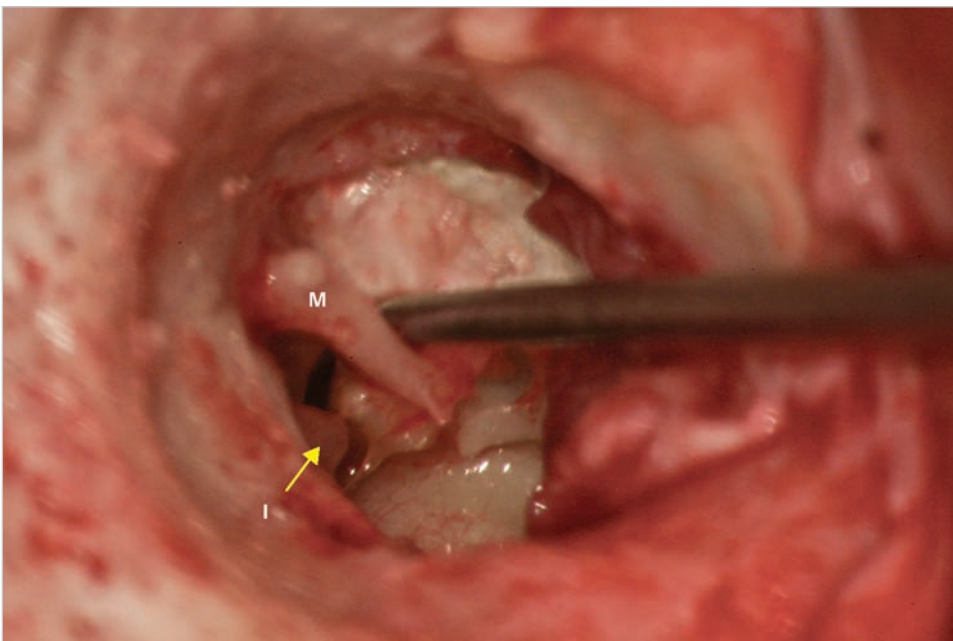


Fig. 8.10 With a tympanic sinus hook, the matrix is dissected from the anterior crus of the stapes. Care should be taken not to break the cholesteatoma matrix, and not to put an excessive force on the ossicular chain. I, incus; M, malleus.

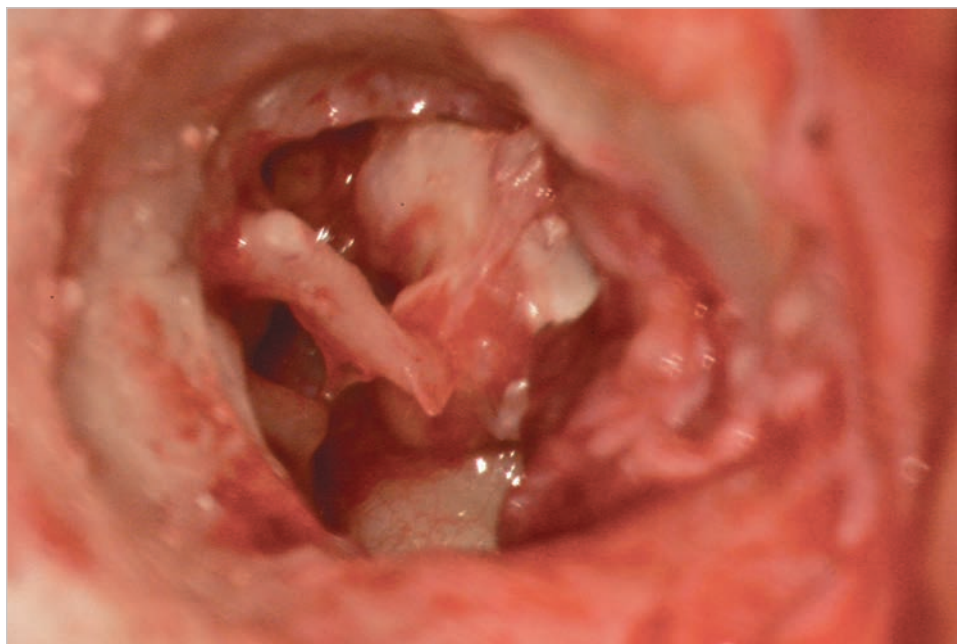


Fig. 8.11 The cholesteatoma freed from the middle ear structures is shown.

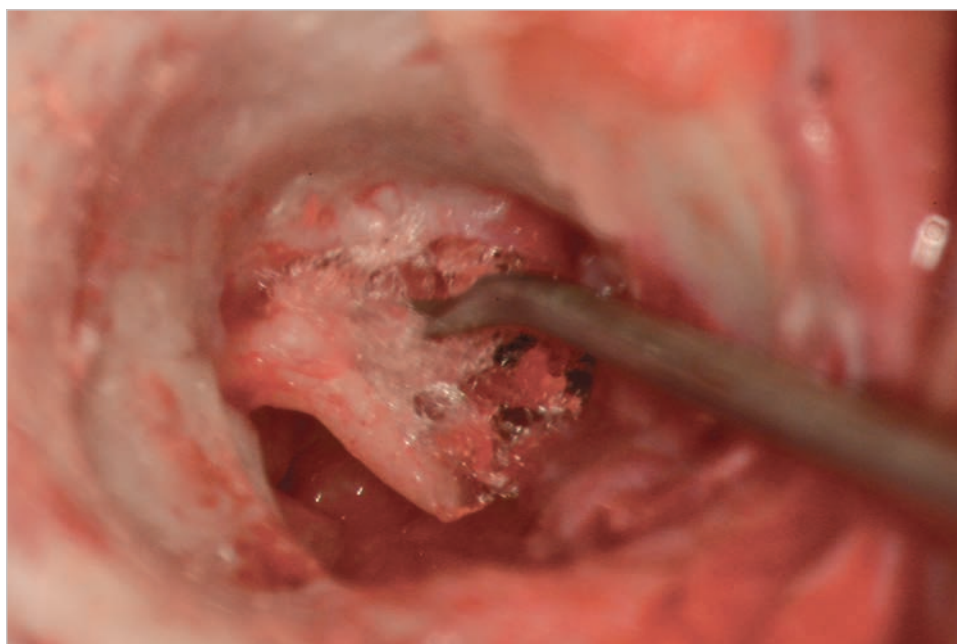


Fig. 8.12 Suspicious areas for residual, especially near the cochleariform process, are rubbed with cottonoid to ensure complete removal of cholesteatoma.

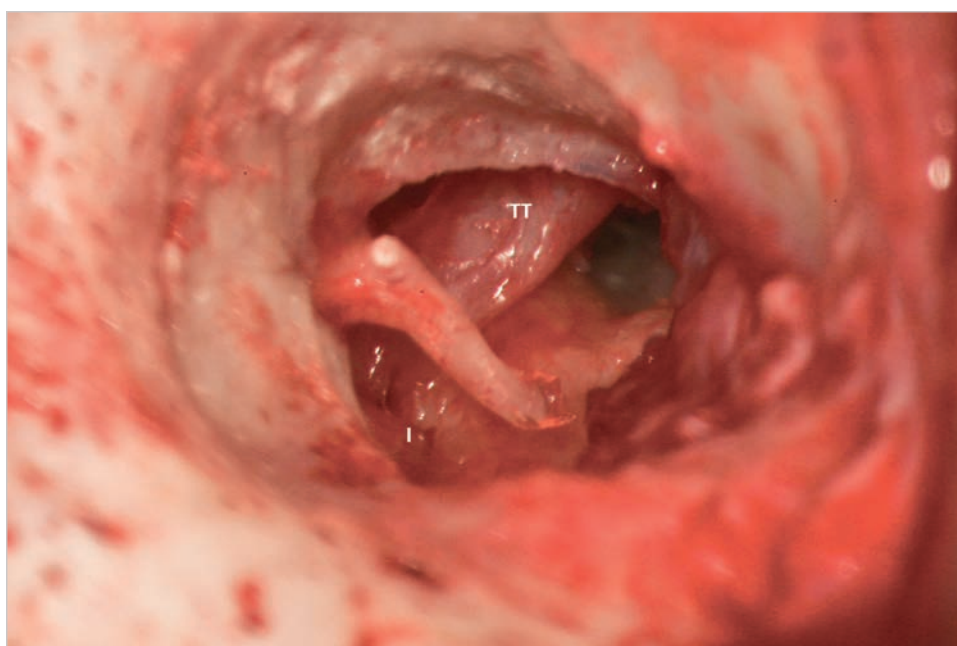


Fig. 8.13 The cholesteatoma is eradicated from the middle ear. The bony bulge courses toward the malleus corresponds to the semicanal for tensor tympani muscle. I, incus; TT, tensor tympani.

Case 8.2 (Right Ear)

See ▶Fig. 8.14, ▶Fig. 8.15, ▶Fig. 8.16, ▶Fig. 8.17, ▶Fig. 8.18, ▶Fig. 8.19, ▶Fig. 8.20, ▶Fig. 8.21, ▶Fig. 8.22, ▶Fig. 8.23, ▶Fig. 8.24, ▶Fig. 8.25, ▶Fig. 8.26, ▶Fig. 8.27, ▶Fig. 8.28, ▶Fig. 8.29.

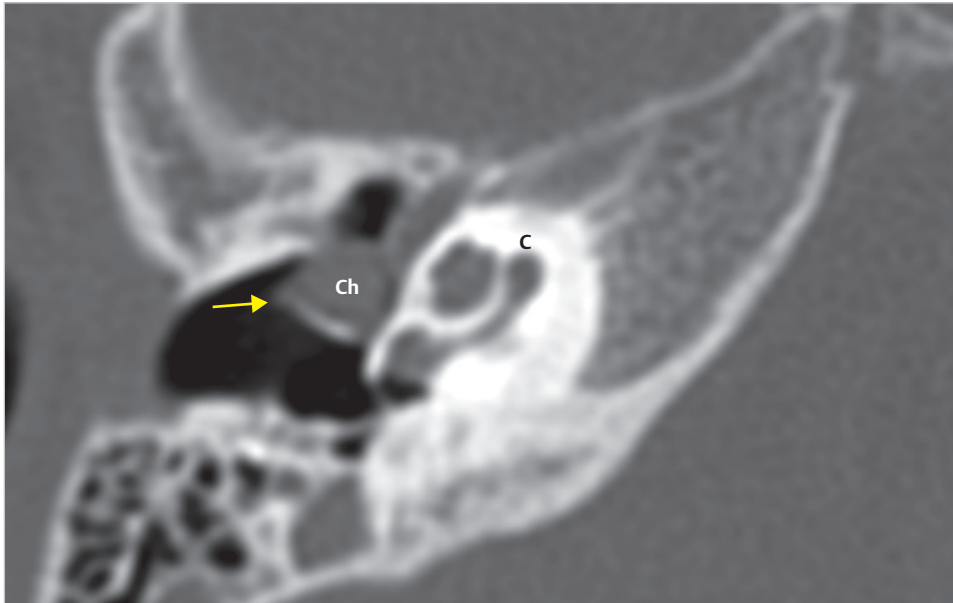


Fig. 8.14 A case of congenital cholesteatoma is shown. A round-shaped mass located to the handle of the malleus (*arrow*) corresponds to cholesteatoma. C, cochlea; Ch, cholesteatoma.

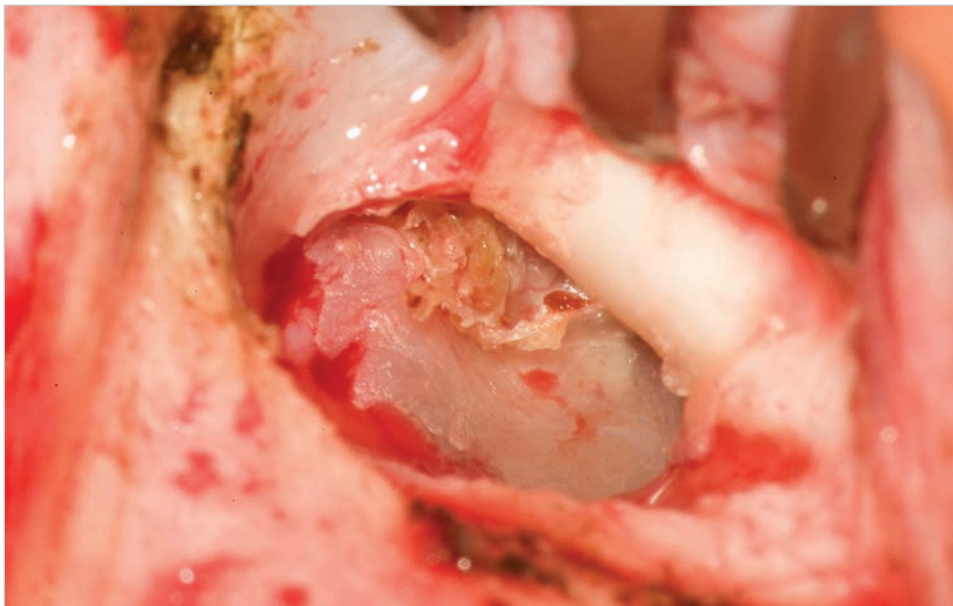


Fig. 8.15 A case of congenital cholesteatoma is shown. To verify presence of cholesteatoma, myringoplasty was conducted elsewhere. Crusting is seen in the anterosuperior quadrant, and whitish mass is seen with transparency beneath the area. Bony protrusion impedes access to the tympanic membrane to some extent.

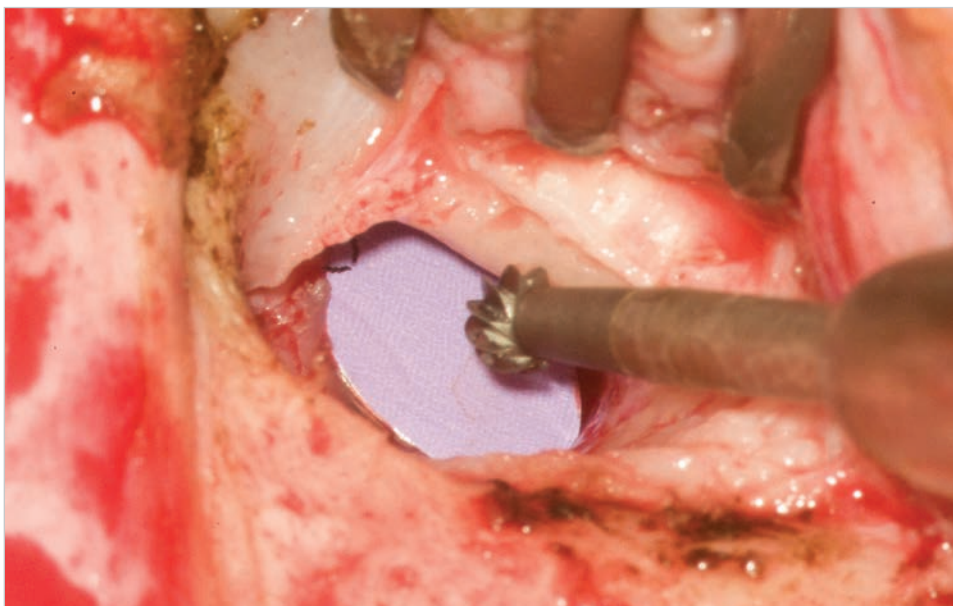


Fig. 8.16 Calibration of the bony meatus is carried out. An aluminum sheeting is used to protect the tympanomeatal flap.

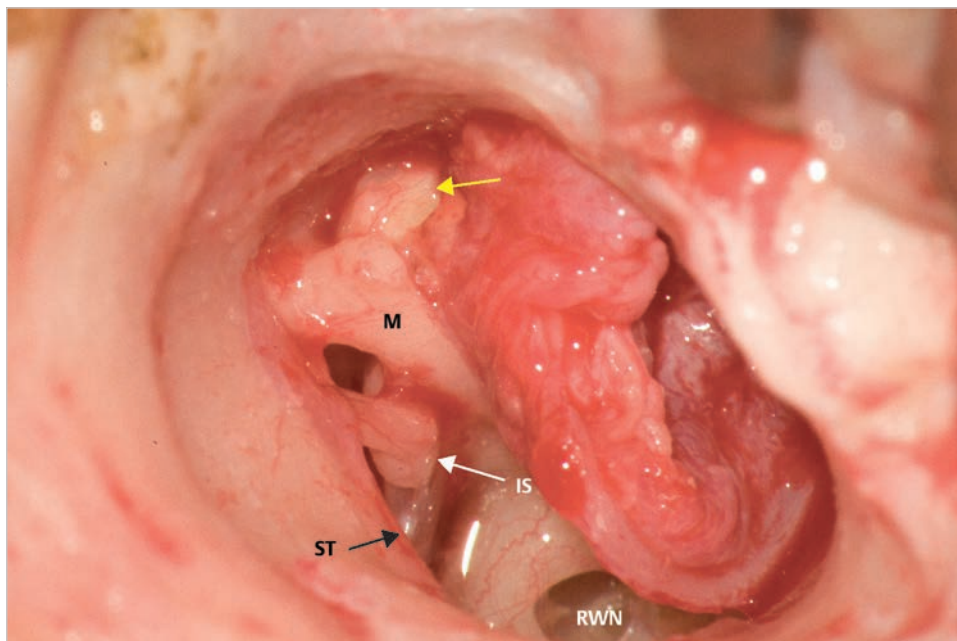


Fig. 8.17 The tympanomeatal flap is elevated and the tympanic cavity is opened. A whitish mass is seen anteriorly to the malleus (*yellow arrow*). No pathology is found in the posterior half of the cavity. IS, incudostapedial joint; M, malleus; RWN, round window niche; ST, tendon of stapedial muscle.



Fig. 8.18 The tympanic membrane is detached from the handle of the malleus. Open-type cholesteatoma is seen. Matrix covers only the superior part of it. Some part of tympanic membrane corresponding to previous myringotomy is adherent to the cholesteatoma and is left in place (*arrow*).



Fig. 8.19 Dissection is carried out from superior pole, and advanced inferiorly along the handle of the malleus.

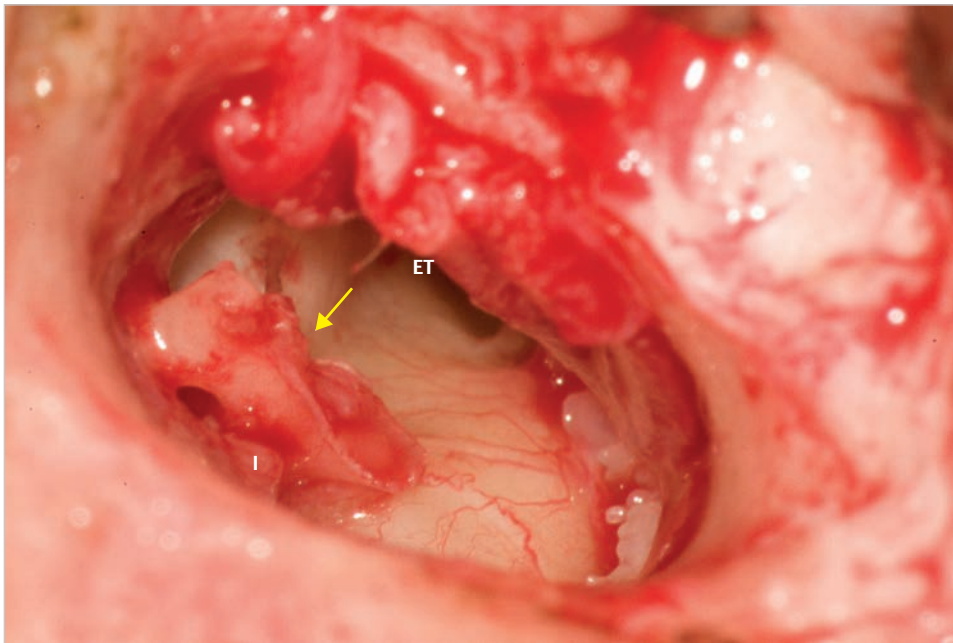


Fig. 8.20 The majority of the cholesteatoma matrix is removed except a small remnant (*arrow*) on the anterior face of the handle of the malleus. ET, eustachian tube; I, incus.

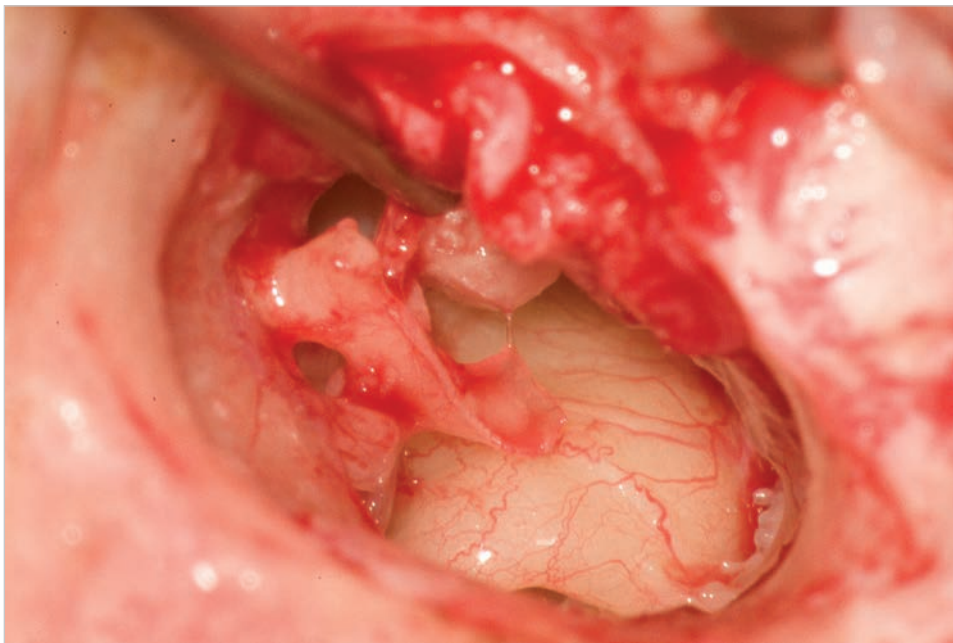


Fig. 8.21 The matrix adherent to the handle of the malleus is removed.

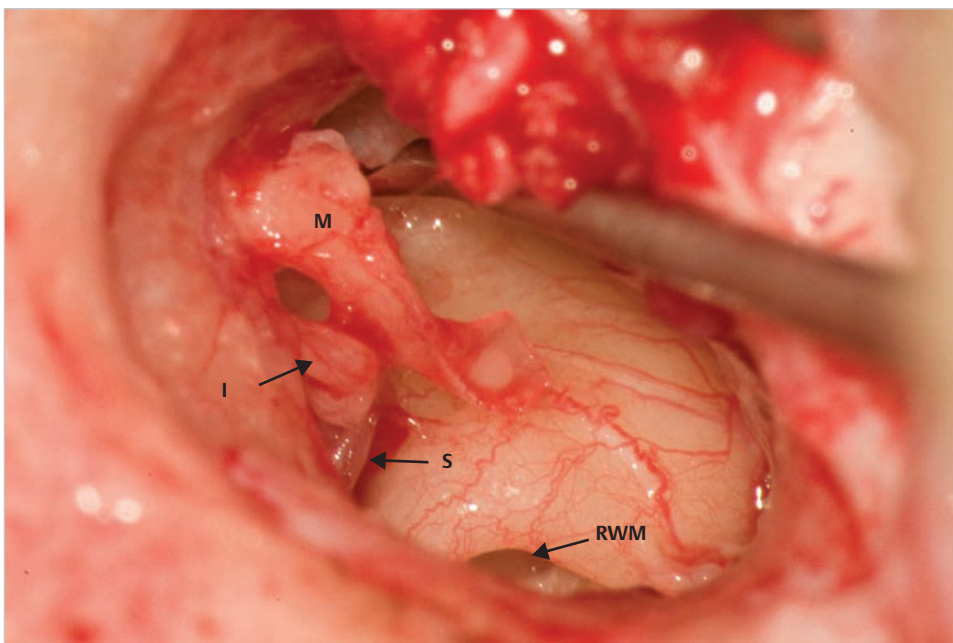


Fig. 8.22 The final piece of matrix located anteriorly to the lateral process of the malleus is removed. Eradication of cholesteatoma from the middle ear is accomplished without disrupting the chain. I, incus; M, malleus; RWM, round window membrane; S, stapes.



Fig. 8.23 The carotid artery (*arrow*) turning anteromedially toward the petrous apex is identified in the inferior wall of the eustachian tube. TT, tensor tympani.



Fig. 8.24 The tympanic cavity is packed with pieces of Gelfoam.

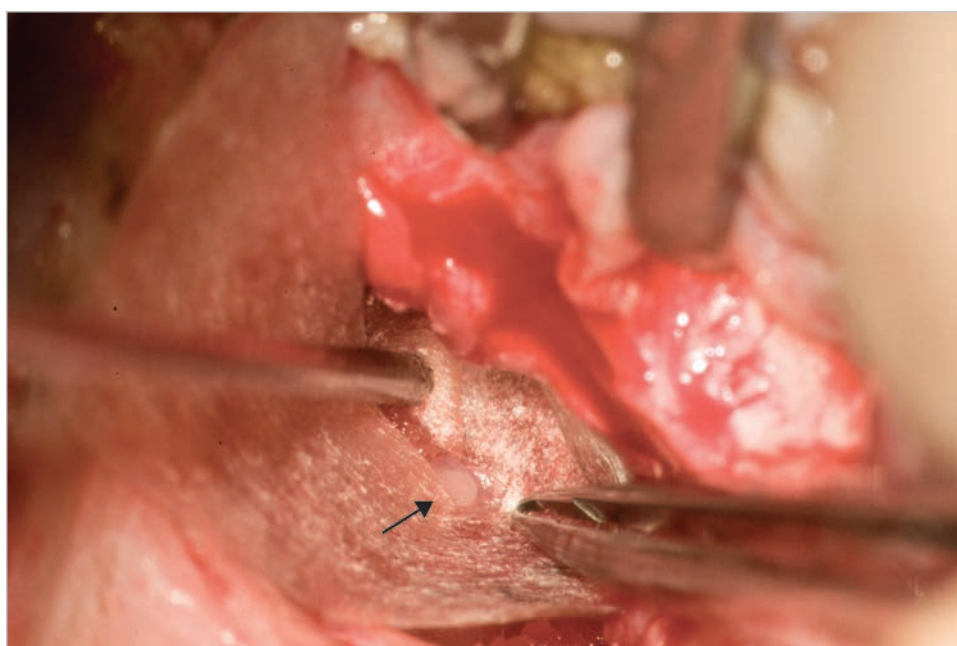


Fig. 8.25 The tip of the handle of the malleus (*arrow*) is passed through a cut made in the fascia.



Fig. 8.26 The handle of the malleus is exteriorized. The arrangement reduces the risk of postoperative lateralization of the tympanic membrane. The fascia should be pushed under the bony annulus anteriorly and inferiorly.

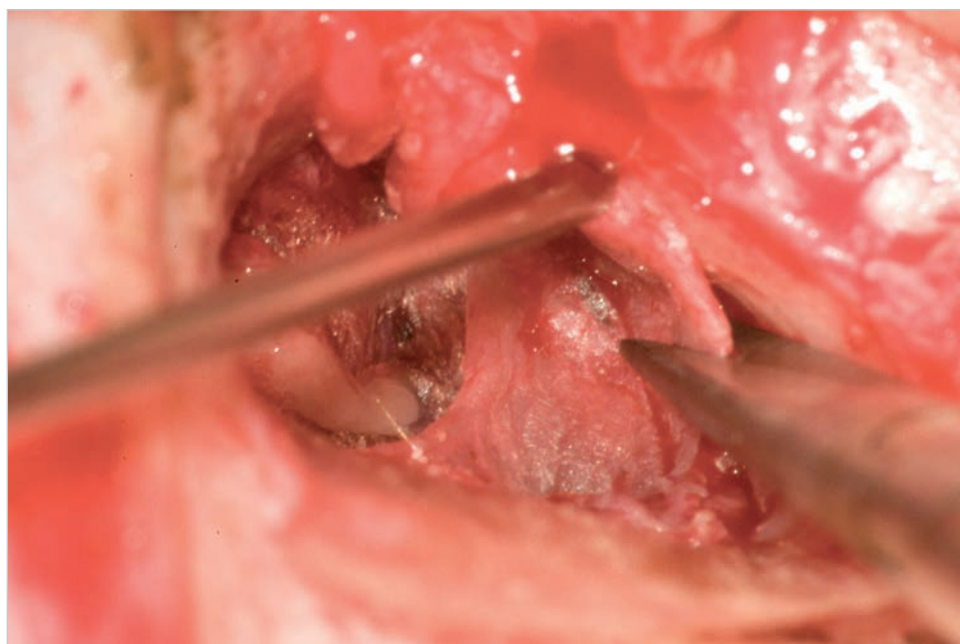


Fig. 8.27 A plastic cut is made in the fascia for adequate contact of the skin to the enlarged meatus.

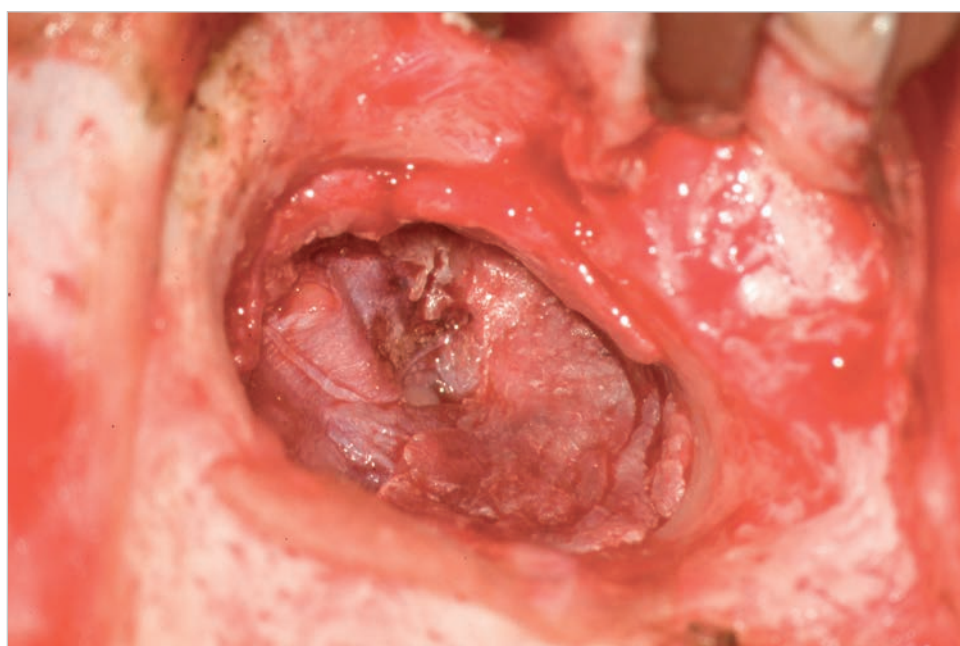


Fig. 8.28 Reconstruction of the tympanic membrane is completed.

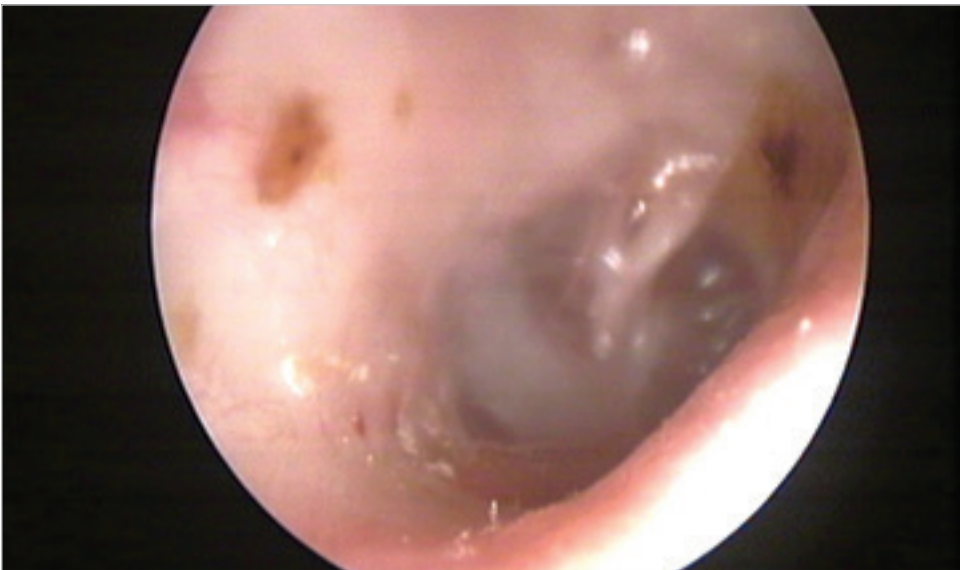


Fig. 8.29 The postoperative otoscopy shows a well-epithelized tympanic membrane.

Case 8.3 (Right Ear)

See ▶ Fig. 8.30, ▶ Fig. 8.31, ▶ Fig. 8.32, ▶ Fig. 8.33, ▶ Fig. 8.34, ▶ Fig. 8.35, ▶ Fig. 8.36, ▶ Fig. 8.37, ▶ Fig. 8.38, ▶ Fig. 8.39, ▶ Fig. 8.40, ▶ Fig. 8.41, ▶ Fig. 8.42, ▶ Fig. 8.43, ▶ Fig. 8.44, ▶ Fig. 8.45, ▶ Fig. 8.46,

▶ Fig. 8.47, ▶ Fig. 8.48, ▶ Fig. 8.49, ▶ Fig. 8.50, ▶ Fig. 8.51, ▶ Fig. 8.52, ▶ Fig. 8.53, ▶ Fig. 8.54, ▶ Fig. 8.55, ▶ Fig. 8.56, ▶ Fig. 8.57, ▶ Fig. 8.58, ▶ Fig. 8.59, ▶ Fig. 8.60, ▶ Fig. 8.61, ▶ Fig. 8.62, ▶ Fig. 8.63, ▶ Fig. 8.64, ▶ Fig. 8.65, ▶ Fig. 8.66.

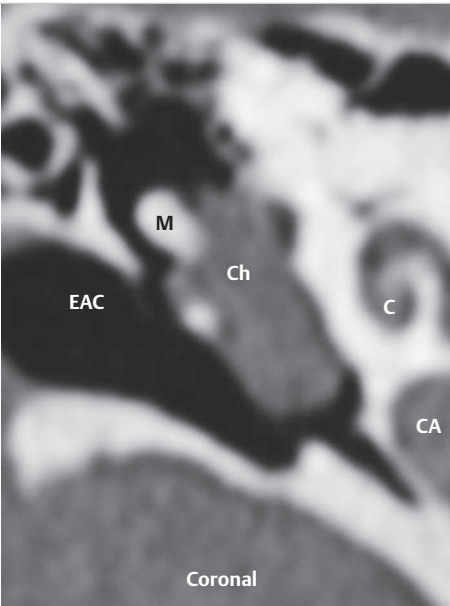
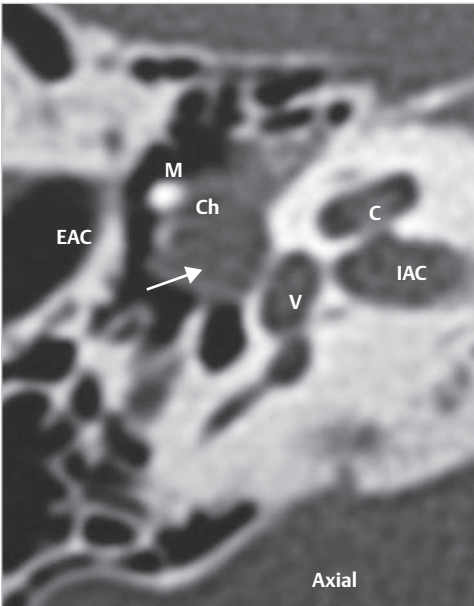


Fig. 8.30 A case of congenital cholesteatoma in an 11-year-old child. On otoscopic examination, a whitish mass is seen in the tympanic cavity with transparency. The CT examination demonstrated that cholesteatoma (arrow) is localized mainly in the tympanic cavity, with small extension toward the attic. The incus is eroded, and continuity of the ossicular chain is impaired. C, cochlea; CA, carotid artery; Ch, cholesteatoma; EAC, external auditory canal; IAC, internal auditory canal; M, malleus; V, vestibule.



Fig. 8.31 Retroauricular incision is conducted, and the tympanic membrane is exposed by elevating a vascular strip. A whitish mass corresponding to the congenital cholesteatoma is seen with transparency in the anterosuperior quadrant of the intact tympanic membrane.

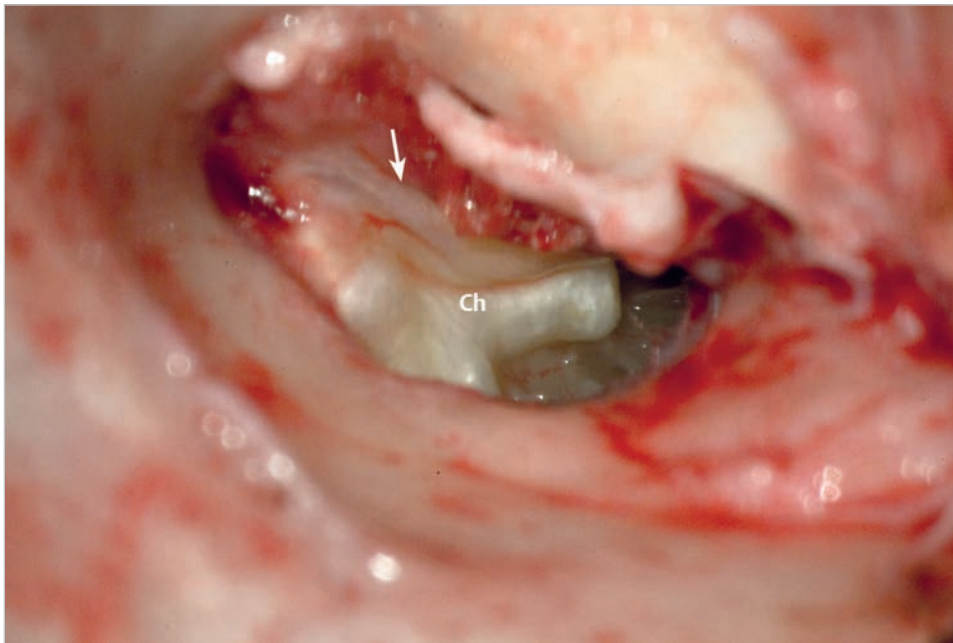


Fig. 8.32 The tympanic cavity is entered by elevating the tympanomeatal flap. Closed-type congenital cholesteatoma (Ch) is seen under the handle of the malleus (*arrow*).

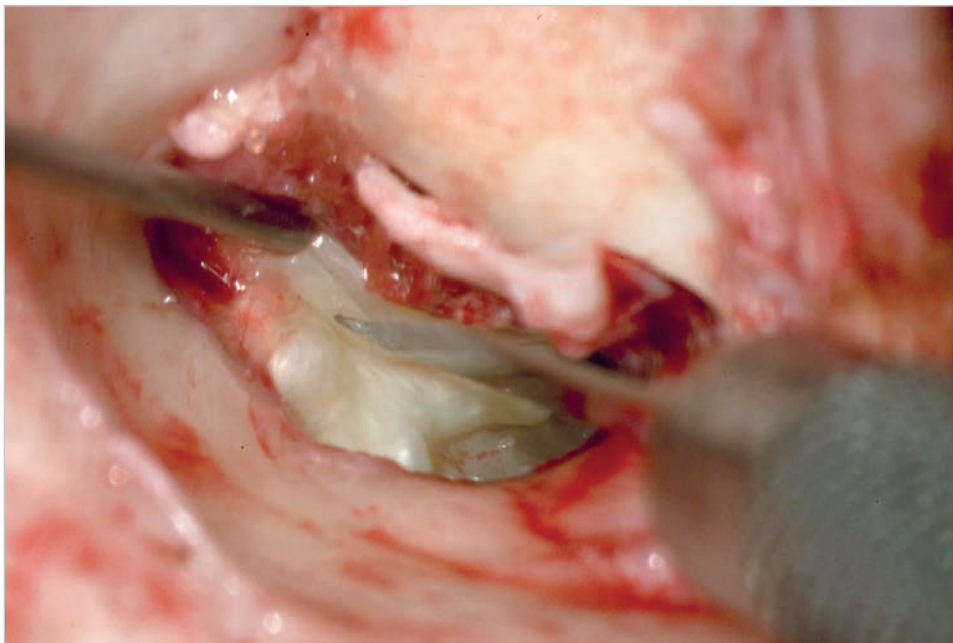


Fig. 8.33 With a sharp knife, the periosteum covering the handle is incised. In cases with intact ossicular chain, care should be taken in this procedure, especially near the tip of the handle. Otherwise, luxation of either the incudomalleal or the incudostapedial joint may occur.

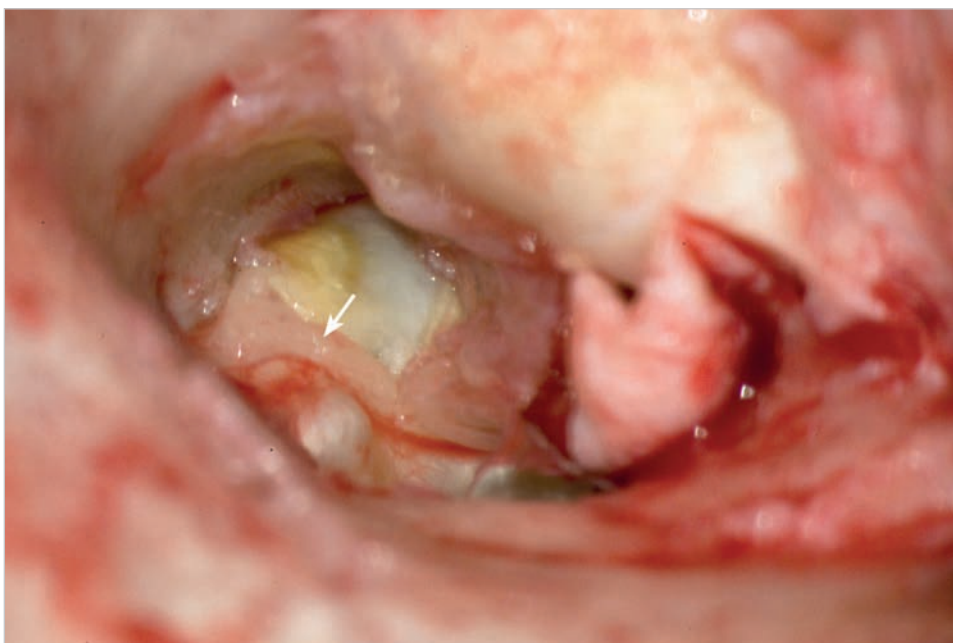


Fig. 8.34 The tympanic membrane is detached from the handle, except from its tip. The tympanic membrane is connected to the tip tightly and may require sharp dissection. The cholesteatoma extends both anteriorly and posteriorly to the handle (*arrow*) and extends beyond the bony annulus.



Fig. 8.35 The tympanic membrane is tightly connected to the tip of the handle and requires sharp dissection in many cases.

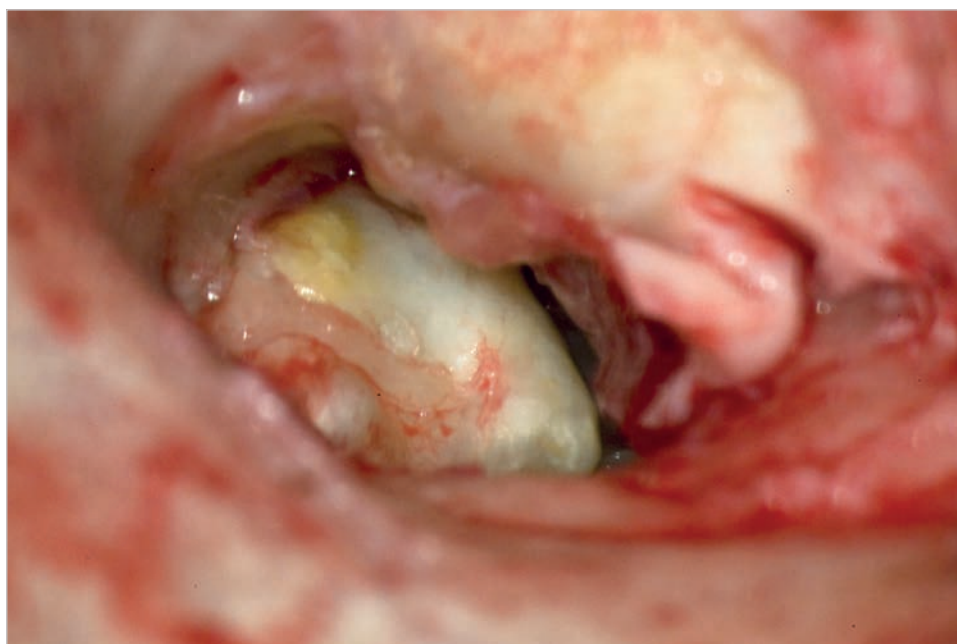


Fig. 8.36 The tympanic membrane is completely detached from the handle, and the cholesteatoma in the tympanic cavity is visualized.



Fig. 8.37 After verification of the discontinuity of the ossicular chain, management of the ossicular chain is started from removal of the malleus. The handle is cut just inferiorly to the lateral process with scissors.

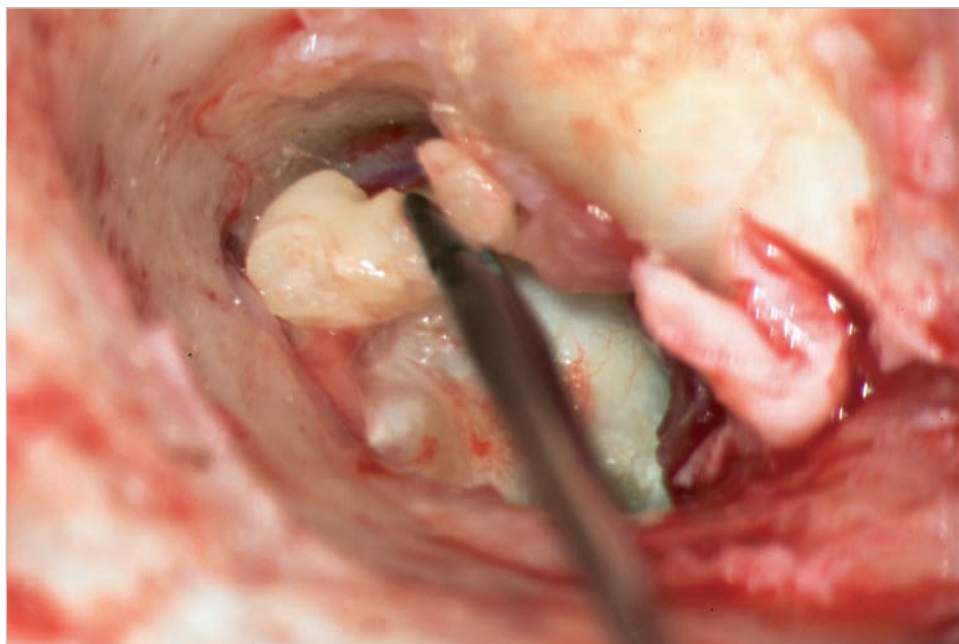


Fig. 8.38 The head of the malleus is removed from the tympanic cavity after cutting the tendon of the tensor tympani muscle.

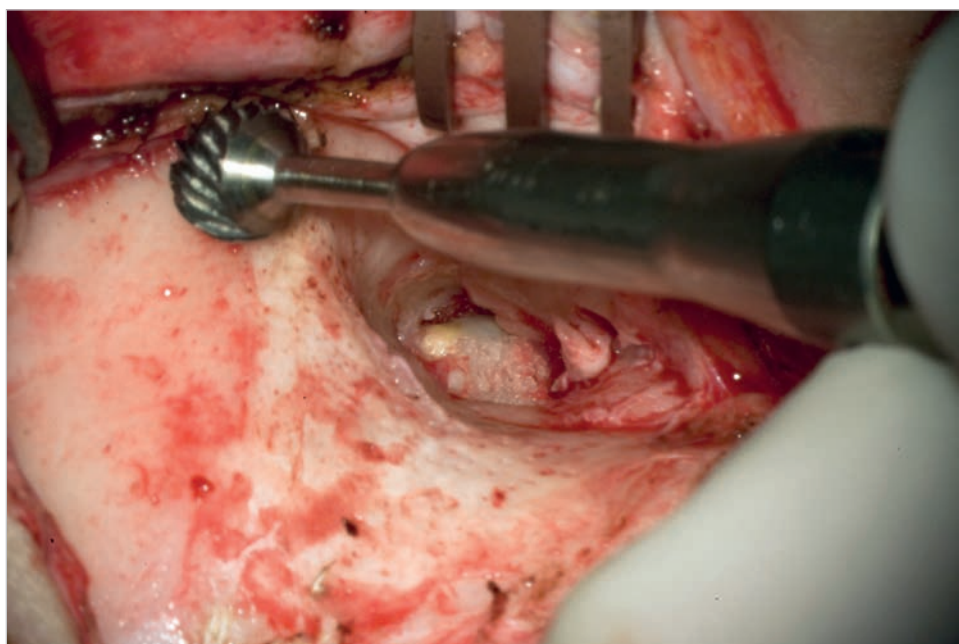


Fig. 8.39 Drilling of the mastoid is started from superior, to identify the middle fossa plate.

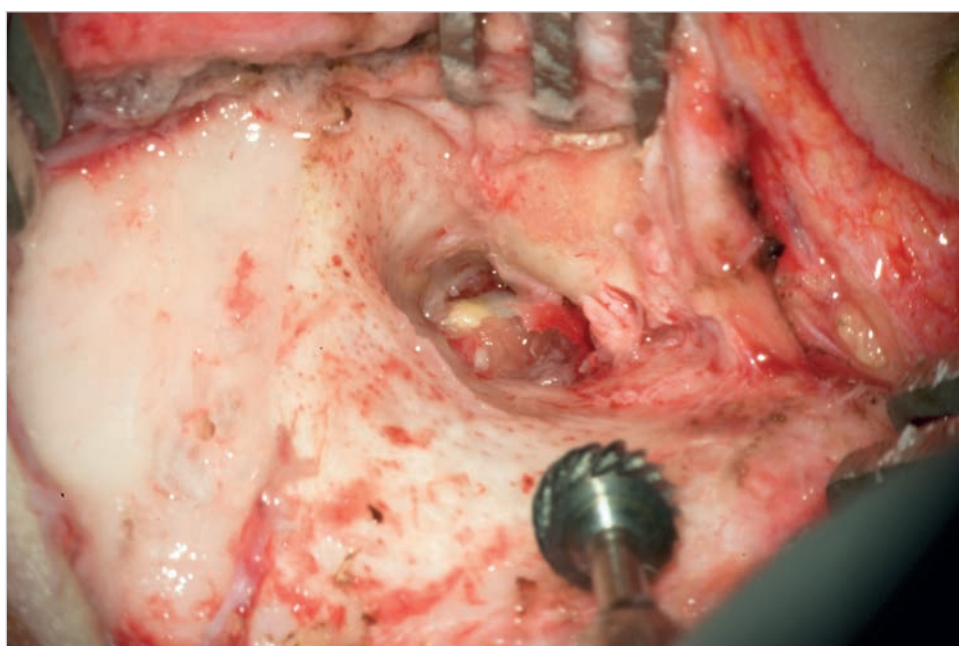


Fig. 8.40 Posteriorly, drilling is conducted to identify the sigmoid sinus.

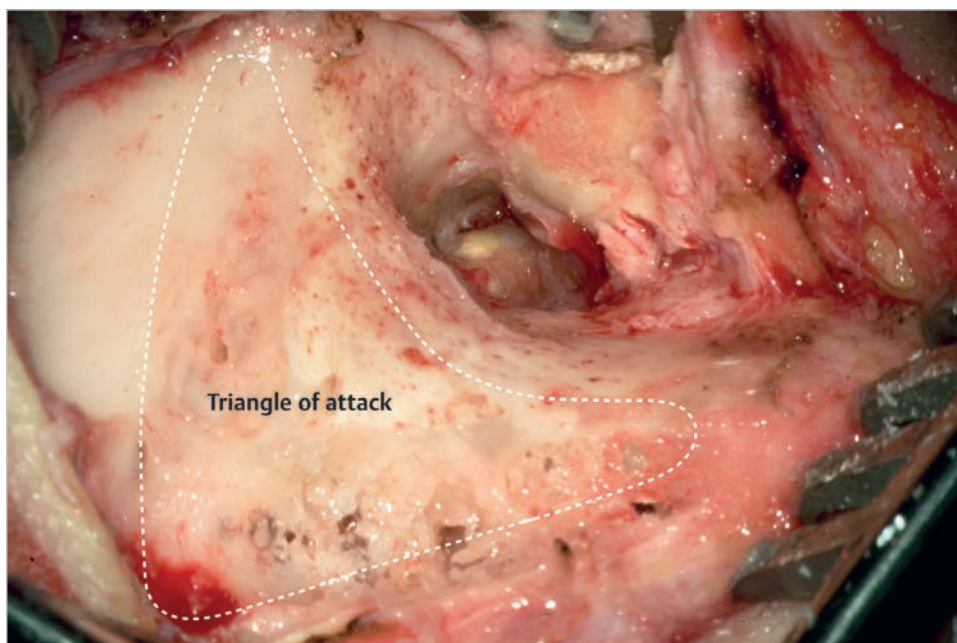


Fig. 8.41 Together with the posterior wall of the bony meatus, these structures form triangle of attack.

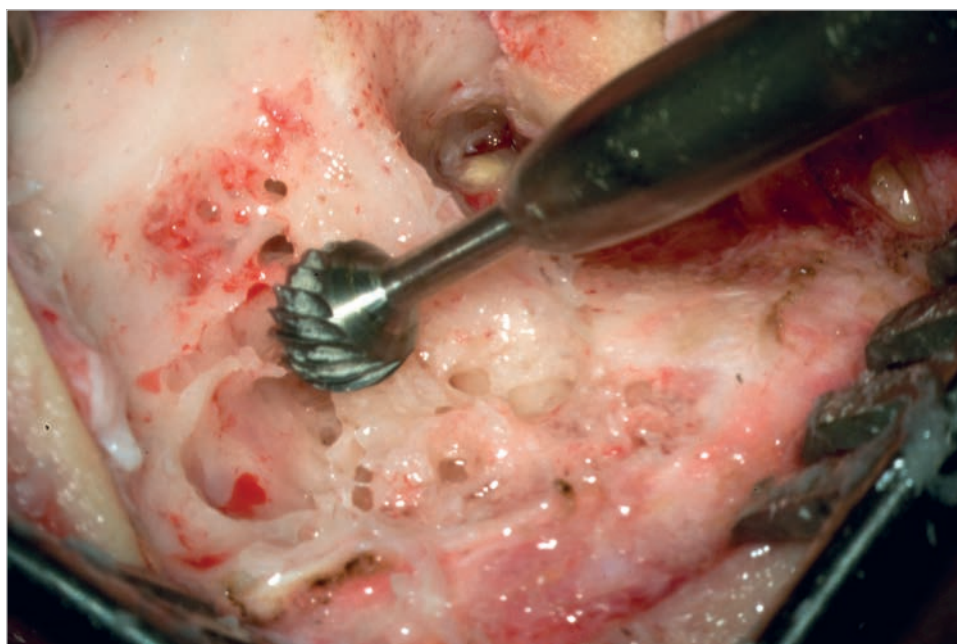


Fig. 8.42 The drilling is advanced medially, with a large cutting burr, with a wide opening but without making bony overhang at the edge. Drilling in this way makes the cavity saucerized in shape and gives surgeon a good access and good visibility.

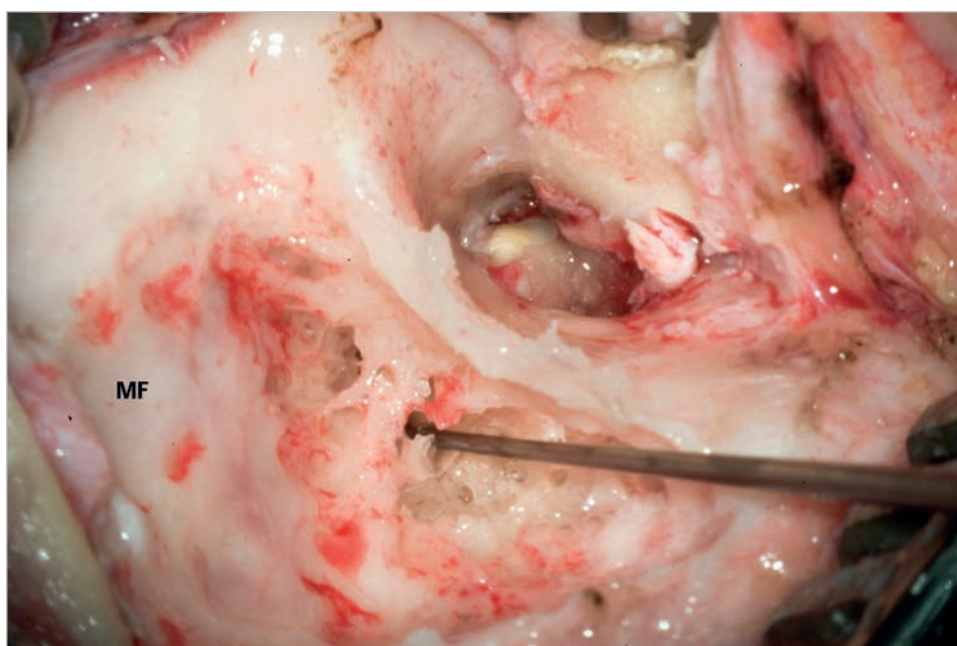


Fig. 8.43 Superiorly, the middle fossa plate is seen. The instrument is inserted toward the antrum. Note the different appearance of the middle fossa plate from surrounding bones. MF, middle fossa.

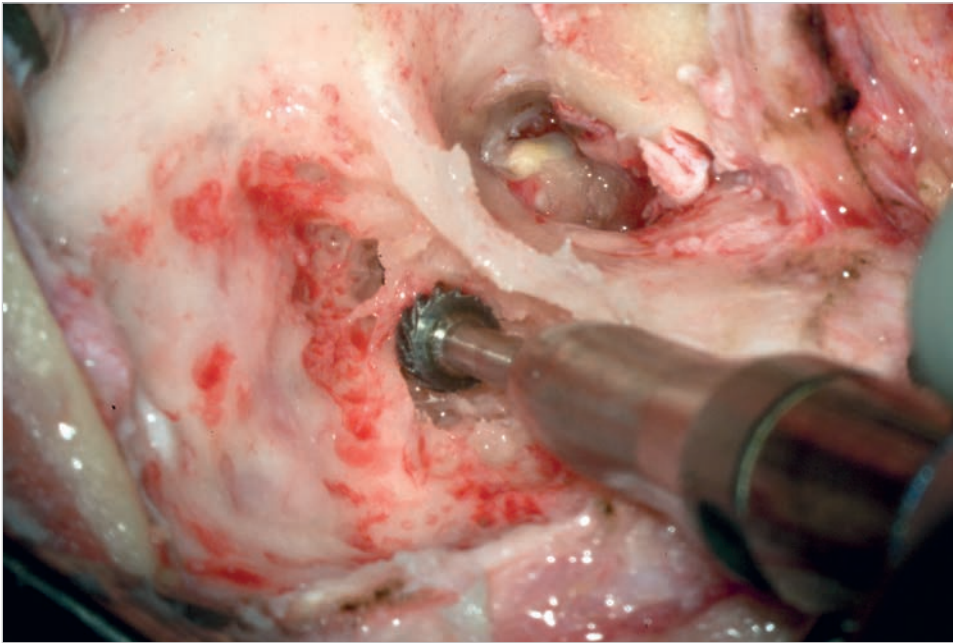


Fig. 8.44 The final bony plate covering the antrum is removed with a large cutting burr.



Fig. 8.45 The antrum is opened. The eminence of the lateral semicircular canal is indicated by the tip of the instrument.

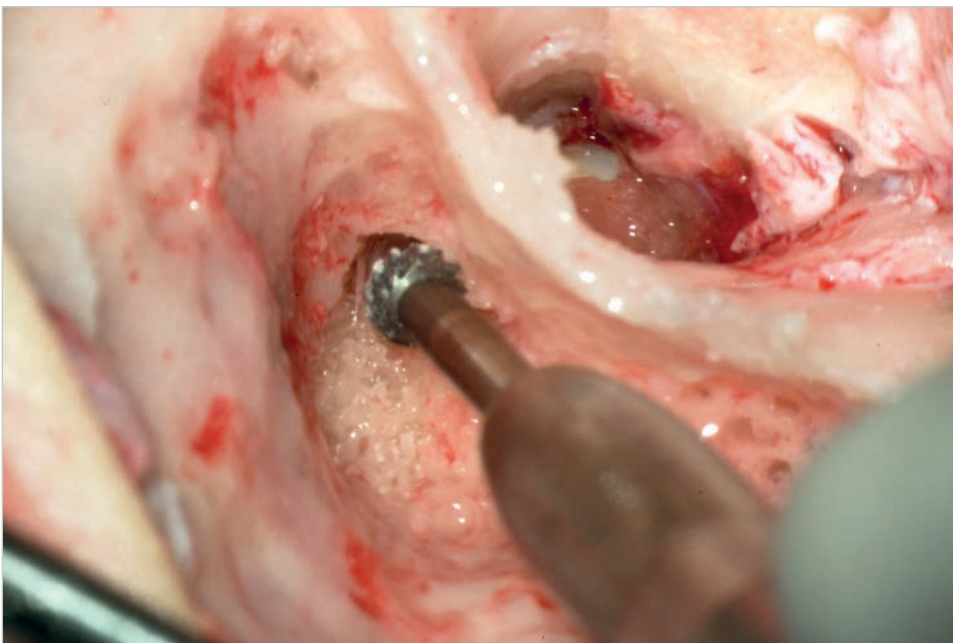


Fig. 8.46 The antrum is opened with a cutting burr. If the ossicular chain is intact, great care should be taken not to drill over the incus. In such cases, it is better to visualize the ossicular chain as soon as possible by opening the sinodural angle, and by shifting the visual axis more posteriorly.



Fig. 8.47 The superior end of the cholesteatoma is visualized. The cholesteatoma occupies the space under the ossicular chain as seen in the preoperative CT.

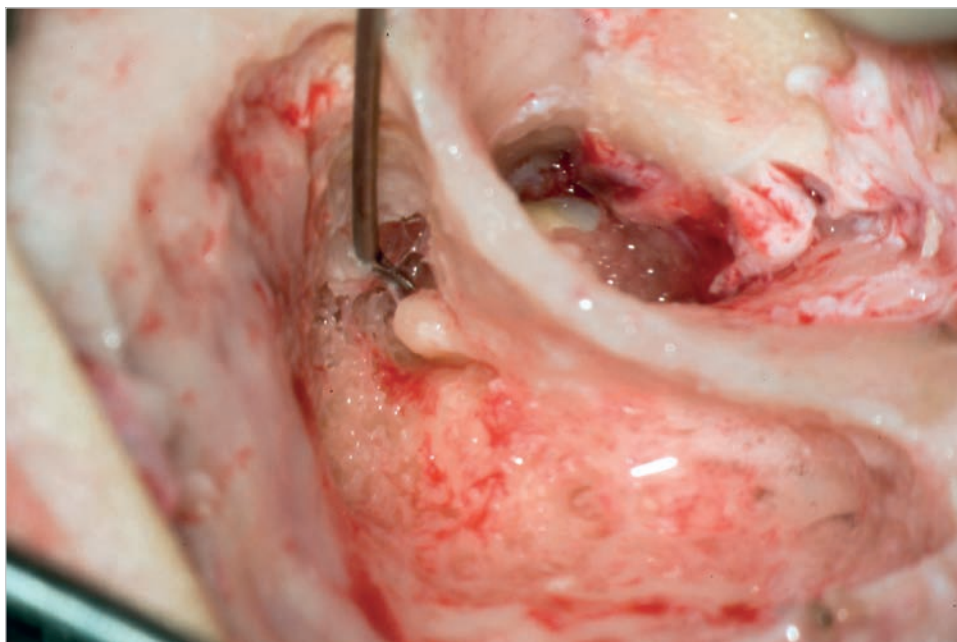


Fig. 8.48 Using a raspatory, the incus is disarticulated, and taken out.



Fig. 8.49 The removed incus with malformation of the long process is shown.

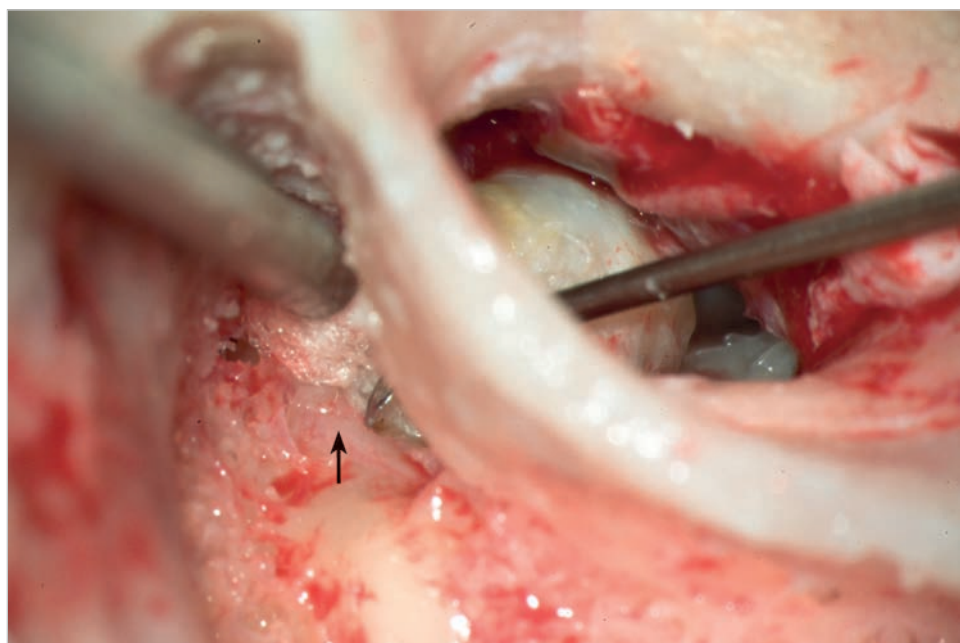


Fig. 8.50 Cholesteatoma is dissected from the tympanic segment of the facial nerve (*arrow*) with a combined approach using cottonoid.

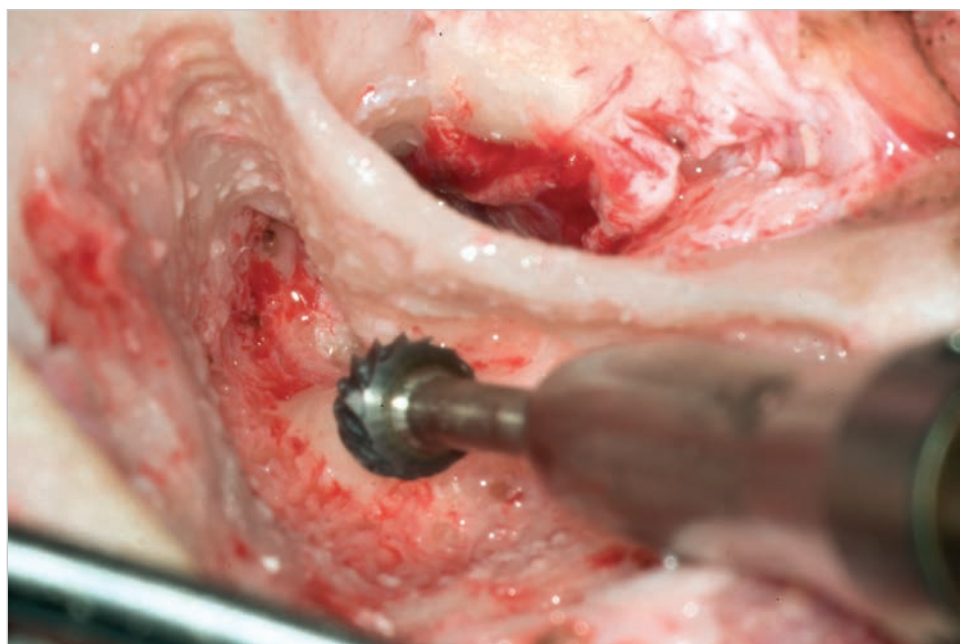


Fig. 8.51 The posterior bony wall is thinned with a large cutting burr.

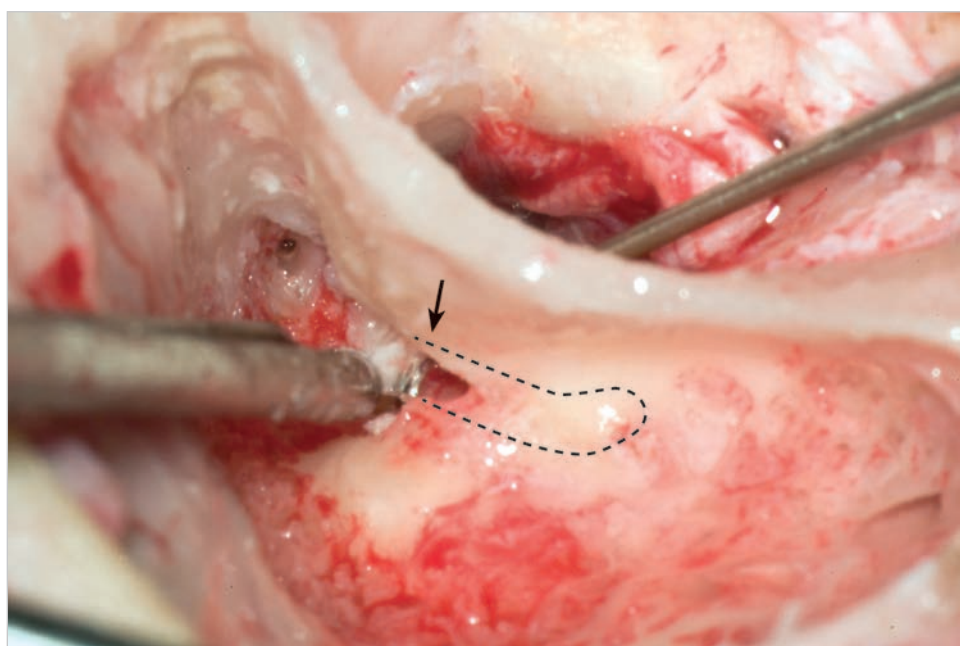


Fig. 8.52 Opening of the fossa incudis (*arrow*) is started, and the matrix occupying the area is removed with a combined approach. The dotted line indicates the area to be drilled.

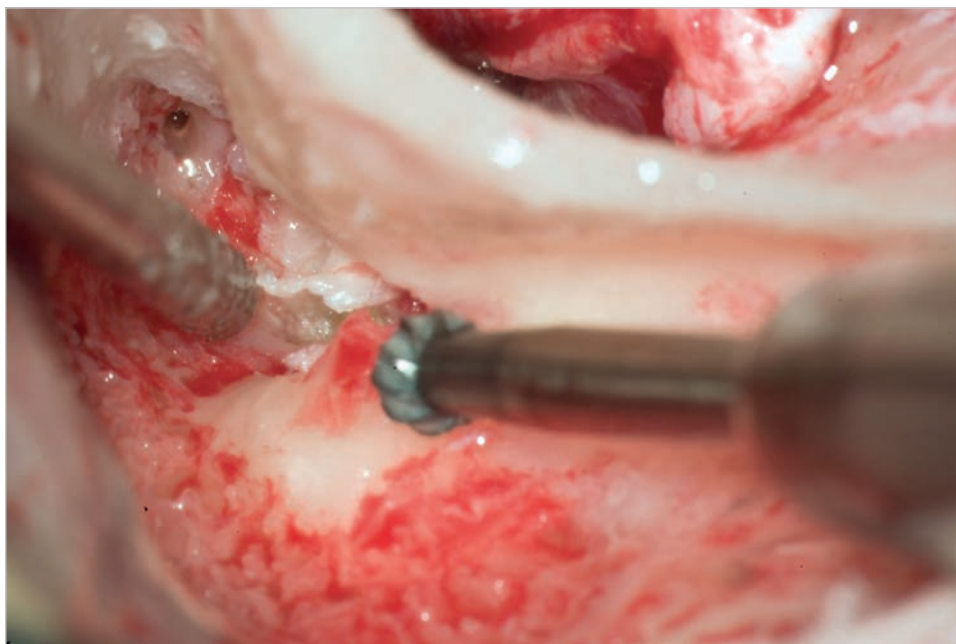


Fig. 8.53 The facial recess lateral to the mastoid segment of the facial nerve is opened with the largest possible cutting burr. The drill should be moved along the facial nerve.

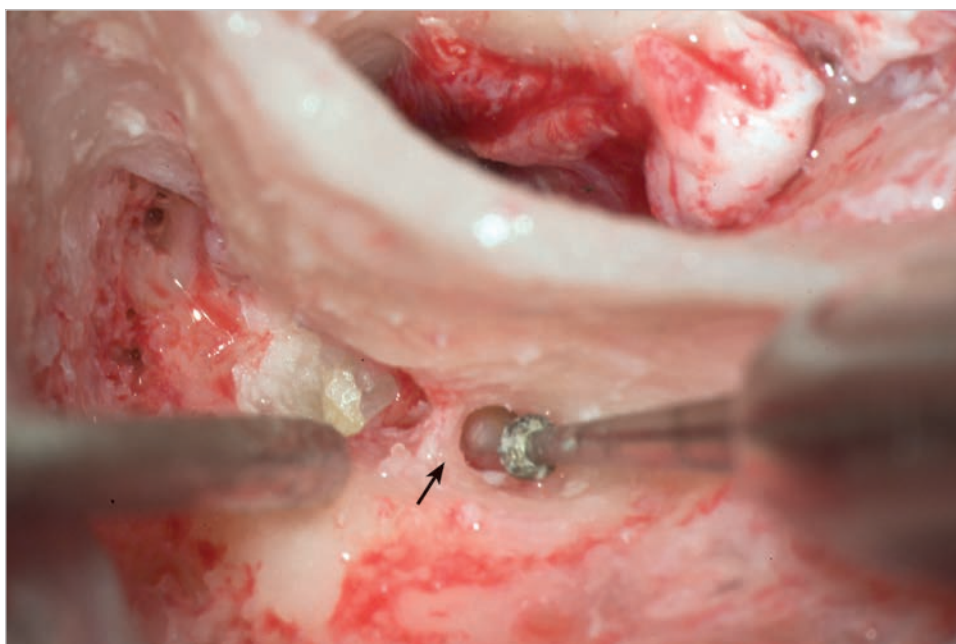


Fig. 8.54 Posterior tympanotomy is in progress using a small diamond burr. The chordal crest is seen (*arrow*). With appropriate maneuver, the area may be drilled with a small cutting. However, meticulous care should be taken in such a case to avoid damaging the facial nerve running just medial to the hole; small cutting burrs easily slip into the cells and may cause serious injury (see Chapter 4).

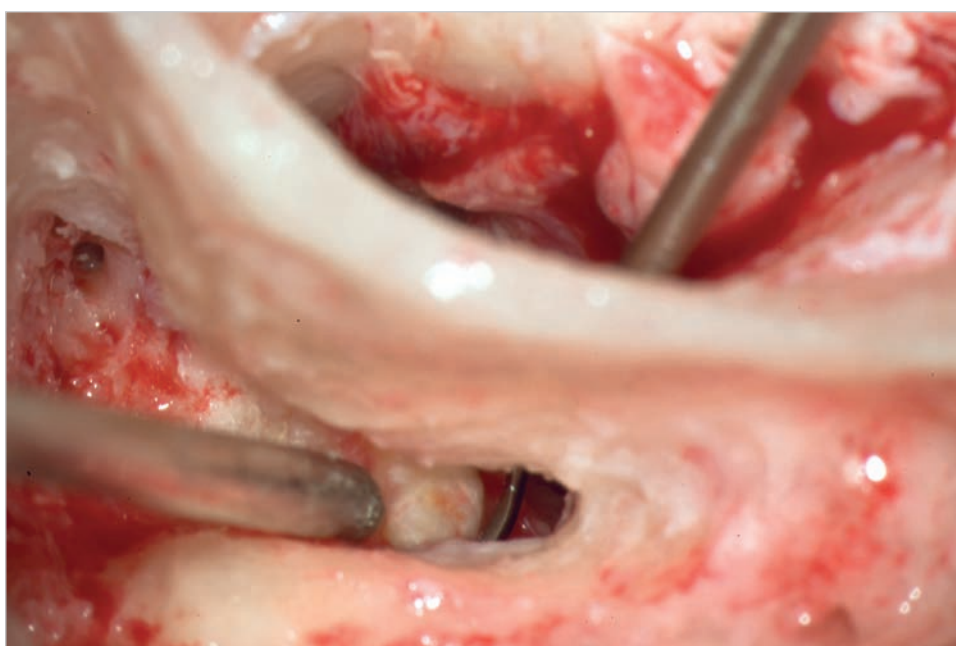


Fig. 8.55 Cholesteatoma covering the stapes and the promontory is removed with a combined approach, using a small dissector inserted from the external auditory canal, and a suction tube from the posterior tympanotomy.

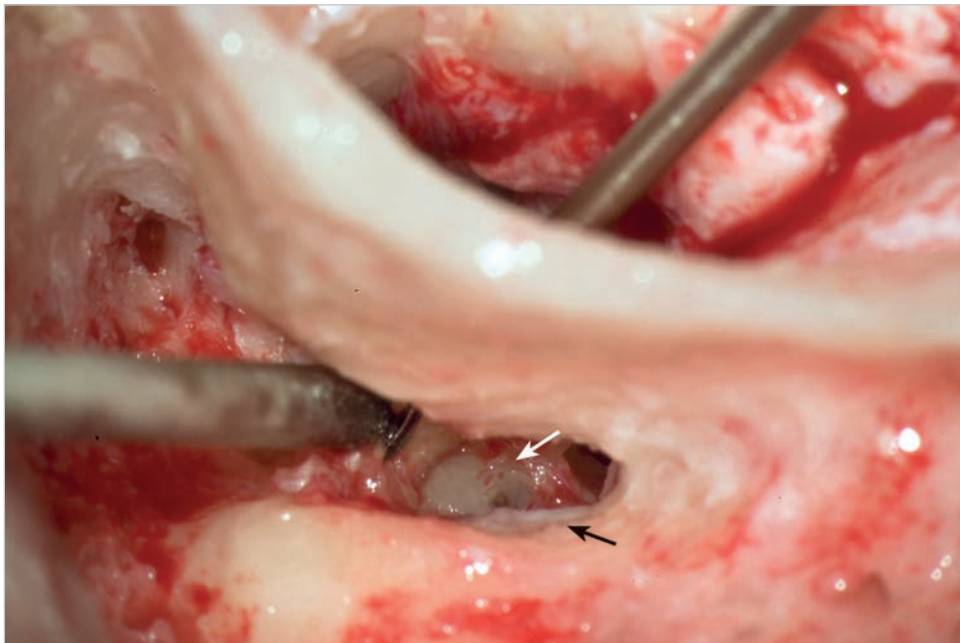


Fig. 8.56 The matrix is detached from the promontory. The lateral edge of the round window niche is seen (*white arrow*). The facial nerve is seen through thin bone as the whitish bundle forming medial border of the posterior tympanotomy (*black arrow*).

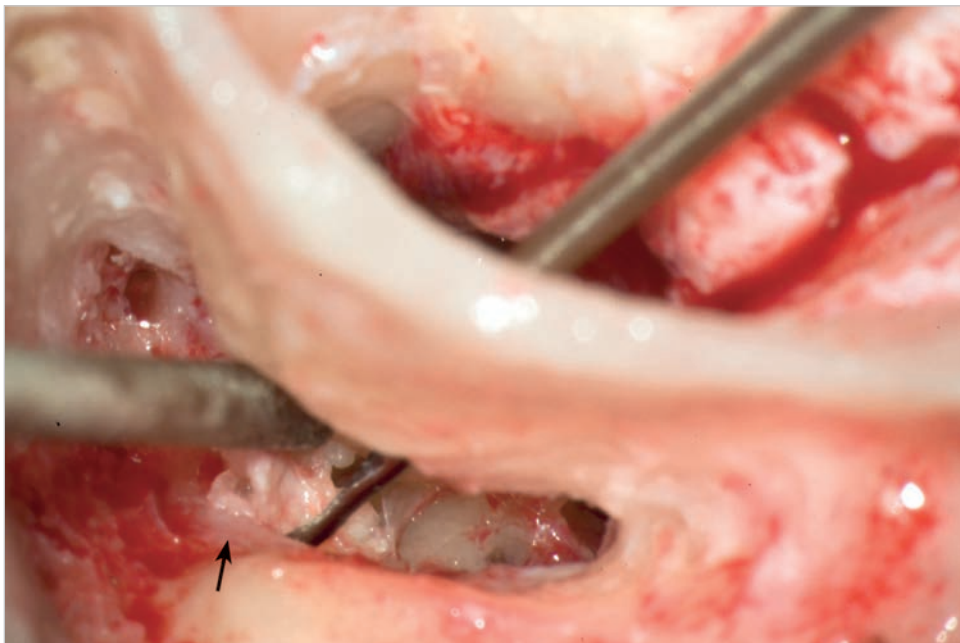


Fig. 8.57 The matrix under the facial nerve (*arrow*) is dissected with the microraspator inserted from the external auditory canal.



Fig. 8.58 The matrix is detached from the promontory.

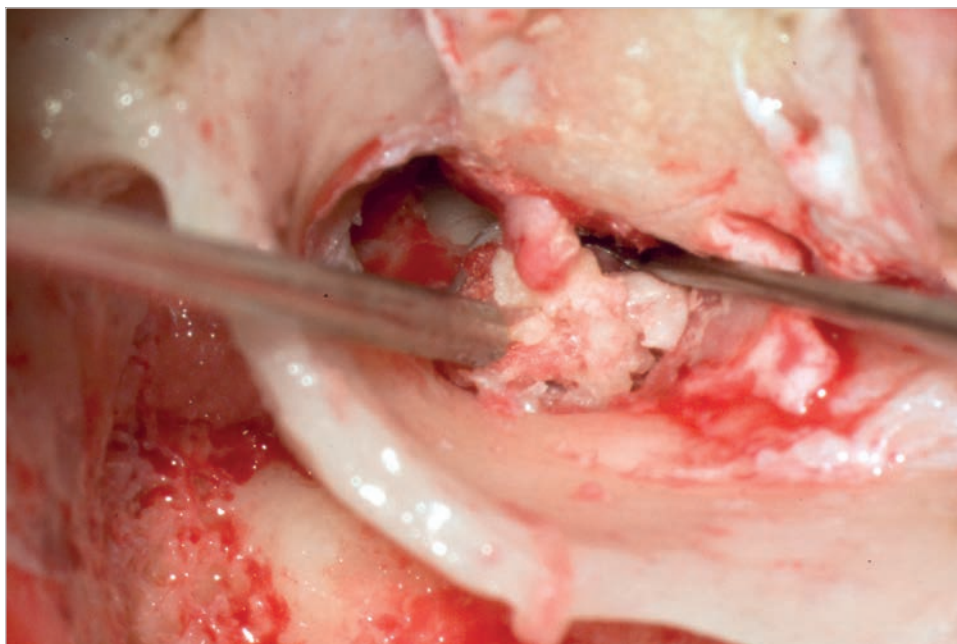


Fig. 8.59 The final part of cholesteatoma is removed from the meatus.

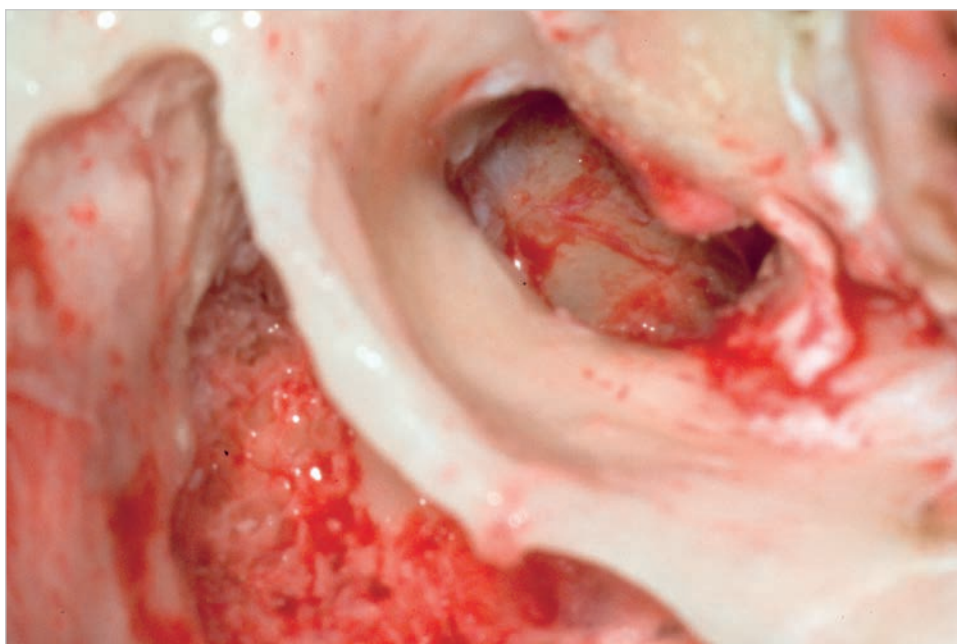


Fig. 8.60 The majority of the cholesteatoma matrix is removed from the middle ear.

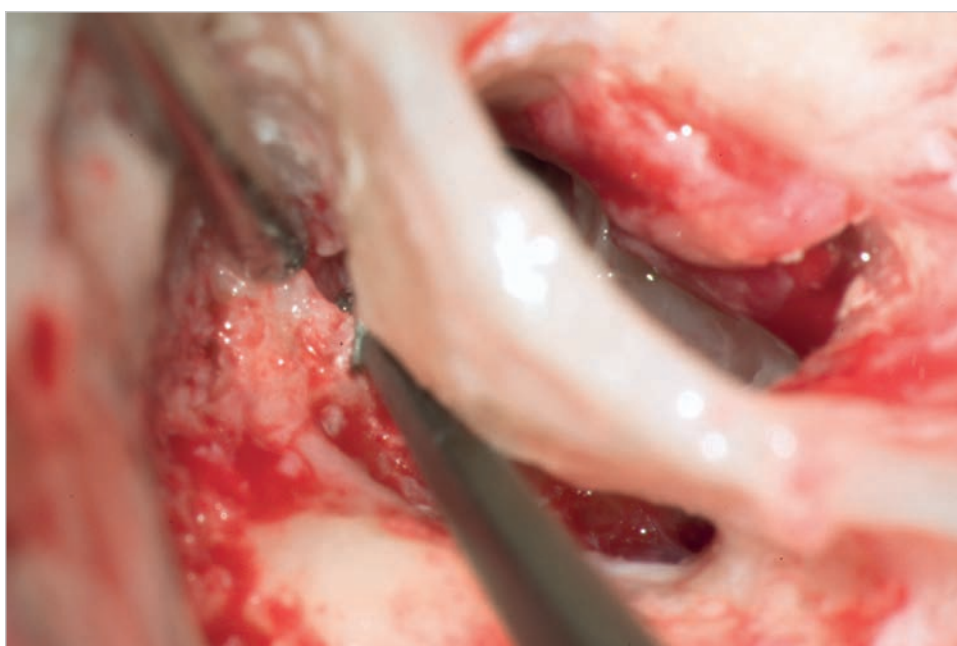


Fig. 8.61 Since a small amount of matrix remains on the cochleariform process, the process is removed with a curette.

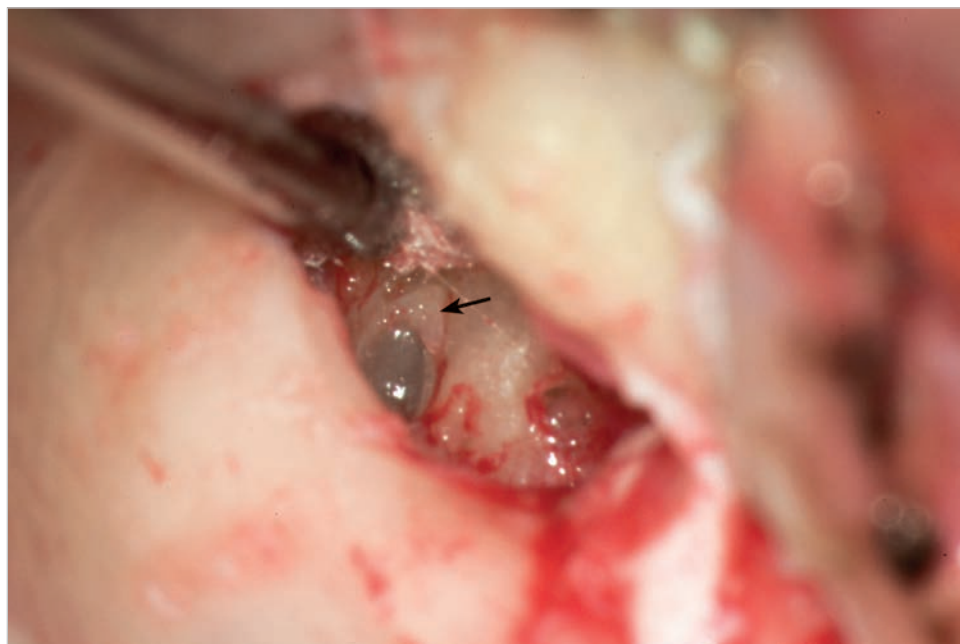


Fig. 8.62 The area of the stapes is explored from the meatus. To control this area, the patient's bed should be turned toward the surgeon. Anomaly is also identified in the stapes. As seen, the majority of the superstructure is missing, except for a hypoplastic posterior crus (arrow).

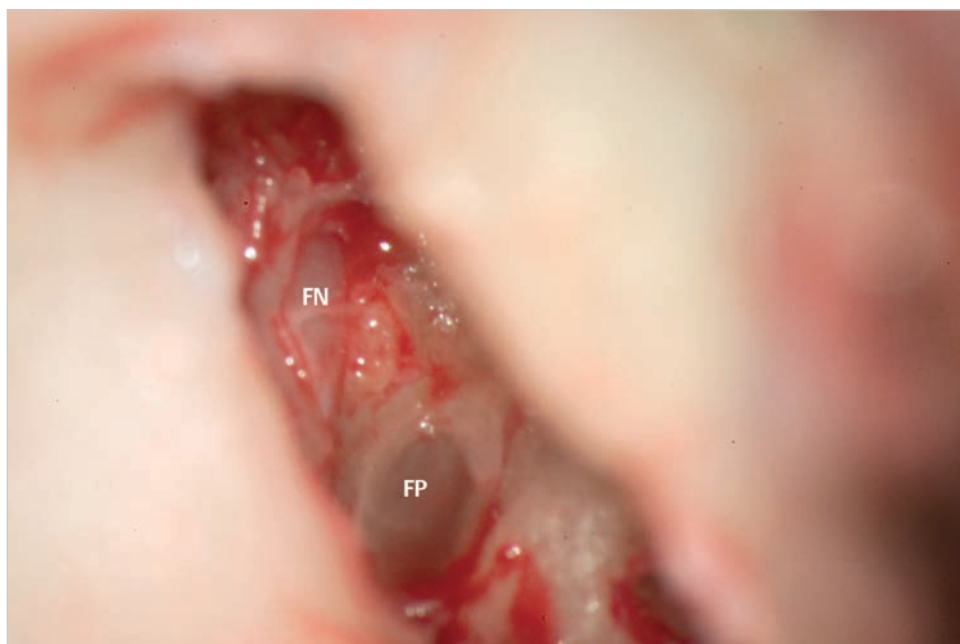


Fig. 8.63 The footplate (FP) and the exposed facial nerve (FN) just superolateral to the footplate are seen from the meatus.



Fig. 8.64 A piece of Silastic sheet designed to cover the medial wall from the eustachian tube to the antrum is introduced into the tympanic cavity through a posterior tympanotomy.

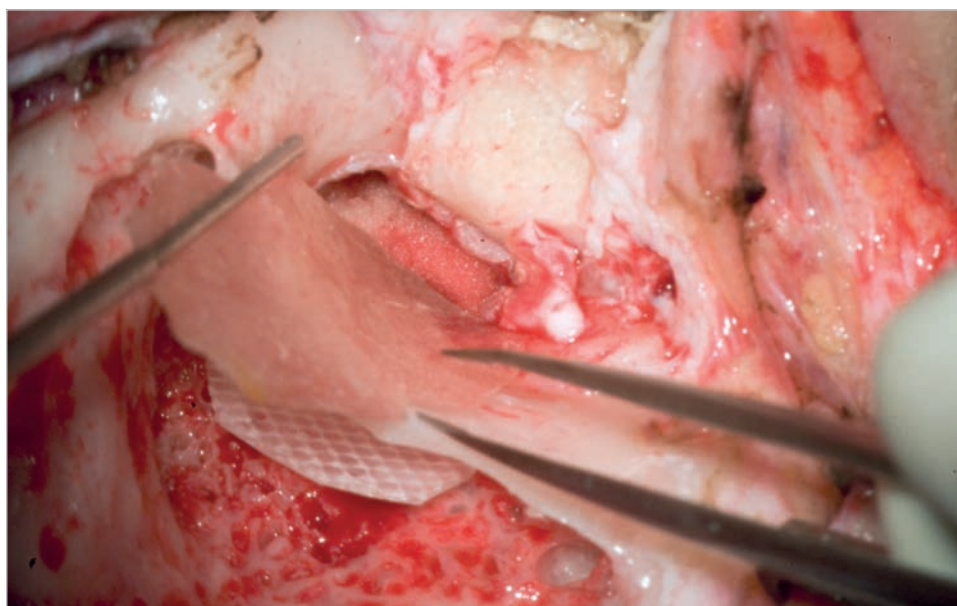


Fig. 8.65 After packing the tympanic cavity with small pieces of Gelfoam placed over the Silastic sheet, a piece of temporalis fascia is grafted underlay.

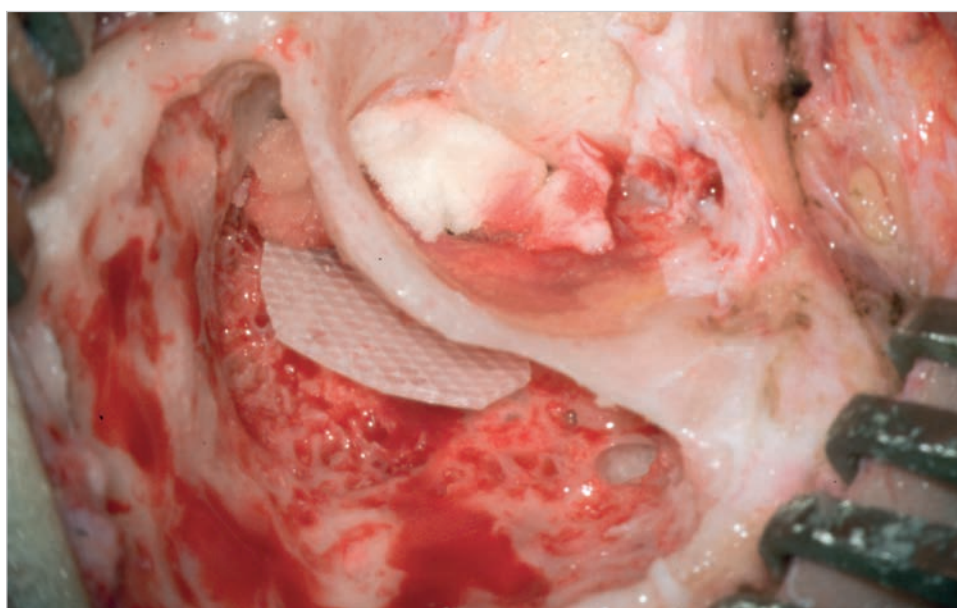


Fig. 8.66 The tympanomeatal flap is replaced over the fascia. The anterior part of the meatus is packed with pieces of Gelfoam. Packing of the external auditory canal is completed through the meatus after replacing the vascular strip over the posterior wall.

Case 8.4 (Right Ear)

See ▶ Fig. 8.67, ▶ Fig. 8.68, ▶ Fig. 8.69, ▶ Fig. 8.70, ▶ Fig. 8.71, ▶ Fig. 8.72, ▶ Fig. 8.73, ▶ Fig. 8.74, ▶ Fig. 8.75, ▶ Fig. 8.76, ▶ Fig. 8.77,

▶ Fig. 8.78, ▶ Fig. 8.79, ▶ Fig. 8.80, ▶ Fig. 8.81, ▶ Fig. 8.82, ▶ Fig. 8.83, ▶ Fig. 8.84, ▶ Fig. 8.85, ▶ Fig. 8.86, ▶ Fig. 8.87, ▶ Fig. 8.88, ▶ Fig. 8.89, ▶ Fig. 8.90, ▶ Fig. 8.91.

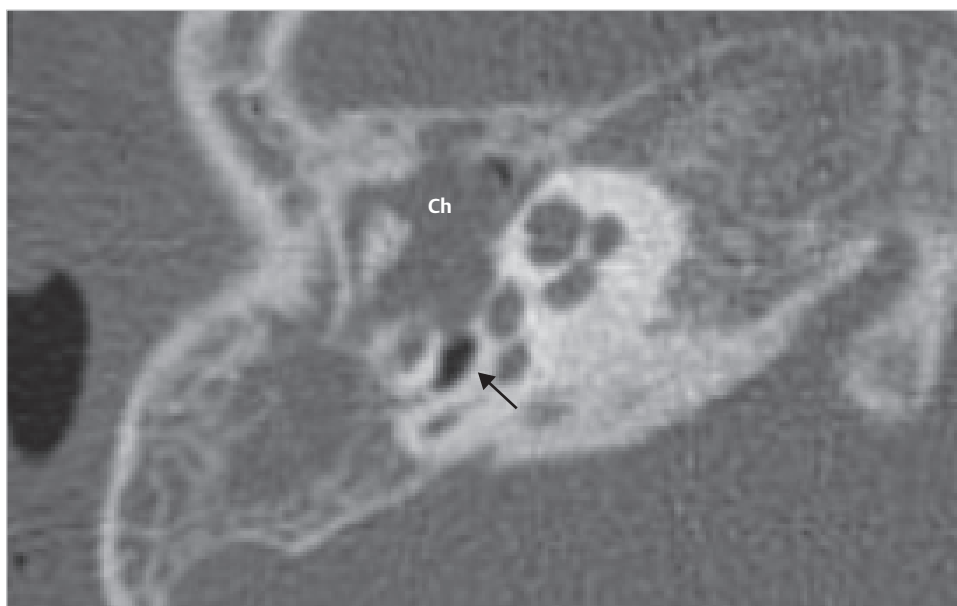


Fig. 8.67 A case of large congenital cholesteatoma in the tympanic cavity. The axial CT demonstrates soft tissue density in the tympanic cavity and the mastoid, and absence of the long process of the incus and the superstructure of the stapes. Note that the tympanic sinus is free of disease, and ventilated (arrow). Ch, cholesteatoma.



Fig. 8.68 The coronal CT demonstrates clear round-shaped mass occupying superior part of the middle ear cleft. Hypotympanum is ventilated well.

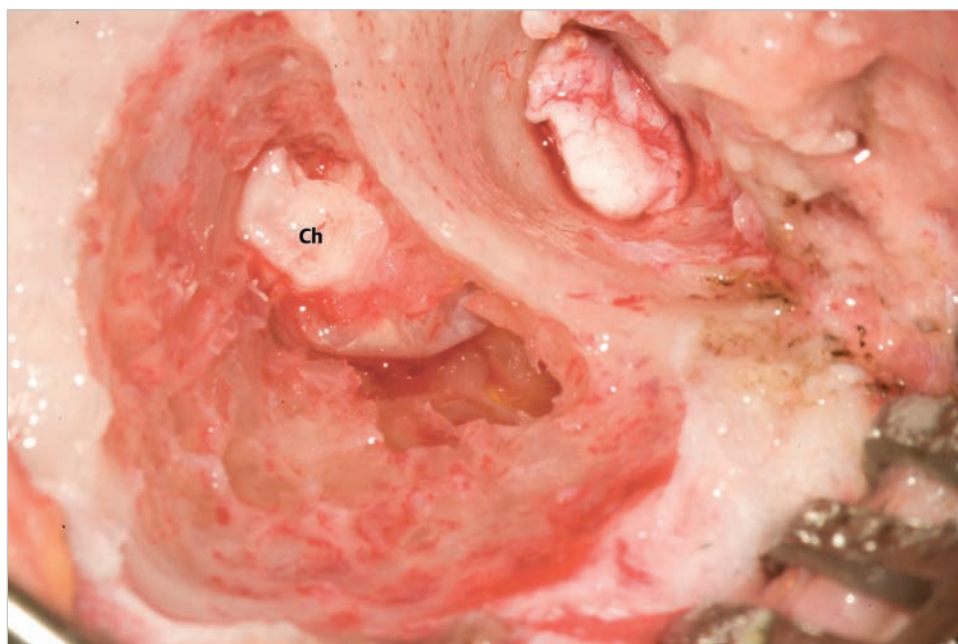


Fig. 8.69 Canal wall up mastoidectomy has been carried out to expose cholesteatoma reaching the antrum. The meatal skin is detached medially. Ch, cholesteatoma.

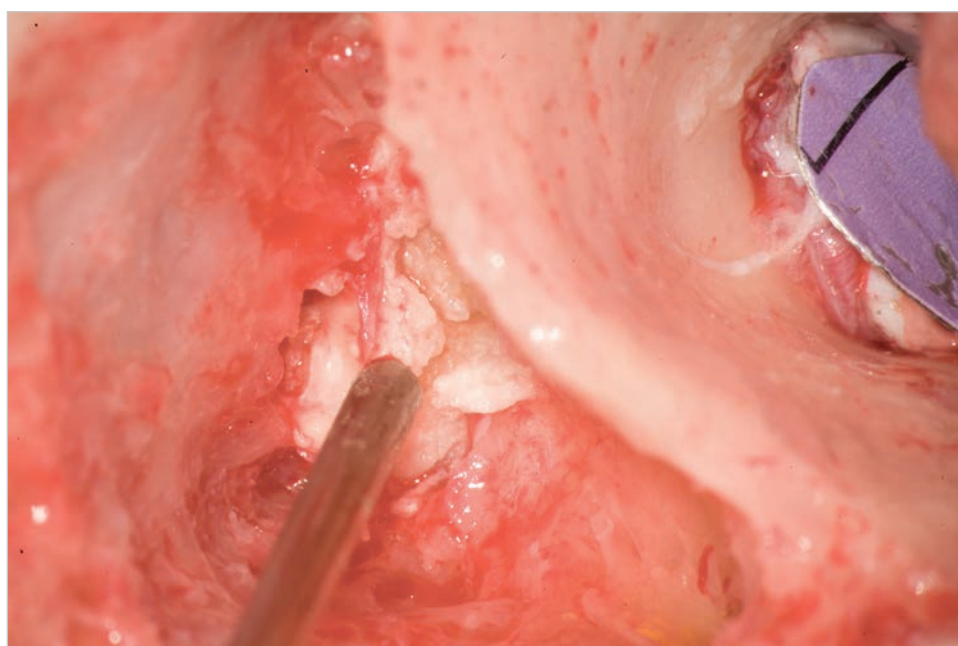


Fig. 8.70 Debulking of cholesteatoma is carried out. Very thin matrix adherent to the irregular tegmen is seen.

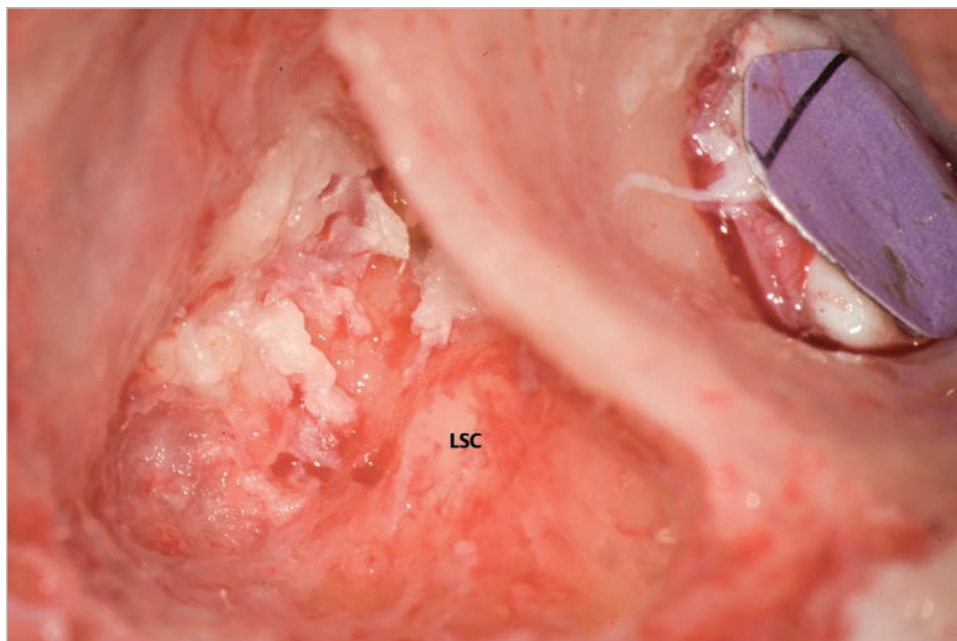


Fig. 8.71 The matrix infiltrating small cells in the tegmen is seen. LSC, lateral semicircular canal.



Fig. 8.72 In cases of congenital cholesteatoma without little middle ear inflammation, the matrix tends to infiltrate small cells, and leaving that matrix results in recurrence as formation of residual cholesteatoma. A small residual invaginating into the cell at the tegmen is shown. The area should be drilled afterward.

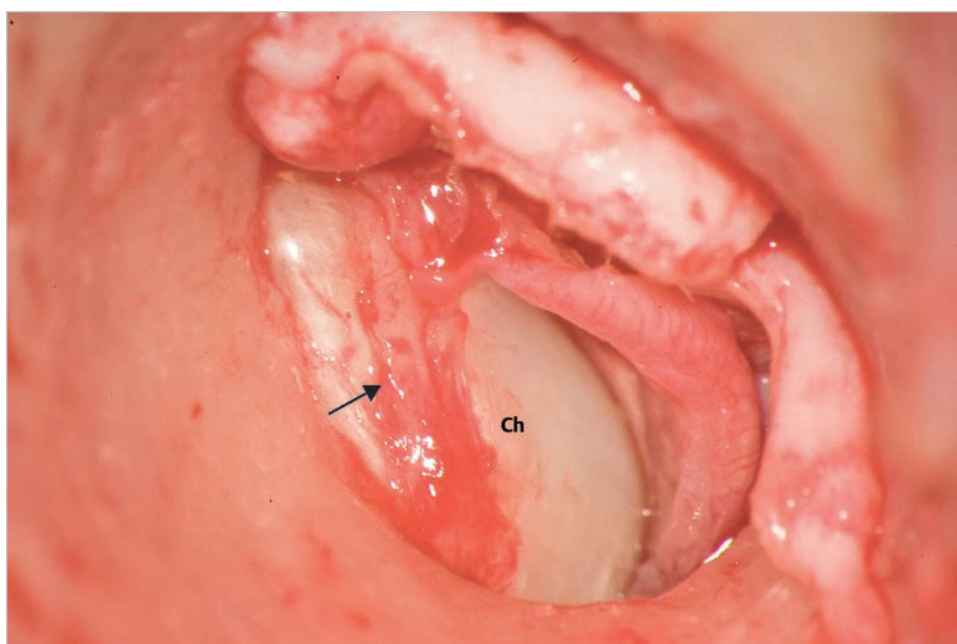


Fig. 8.73 The tympanomeatal flap is elevated, and the tympanic cavity is opened. The posterior half of the tympanic cavity is completely filled with cholesteatoma. The chorda tympani nerve coursing over the cholesteatoma is seen (arrow). Ch, cholesteatoma.



Fig. 8.74 The chorda tympani nerve is severed. Dissection of the large cholesteatoma is started from debulking through the lateral face.

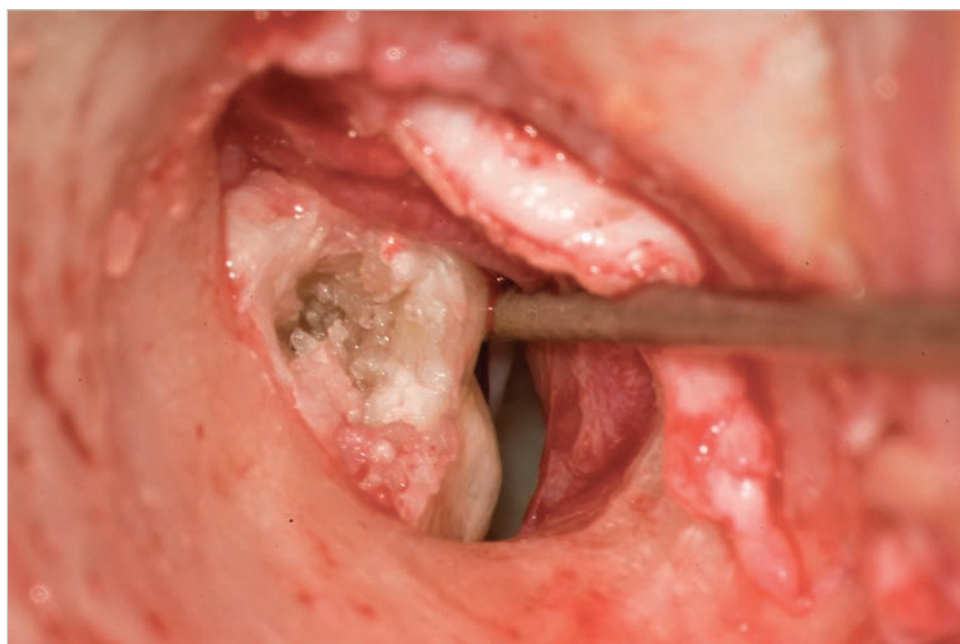


Fig. 8.75 Debulking of cholesteatoma makes room for dissection of the matrix from the hypotympanum.

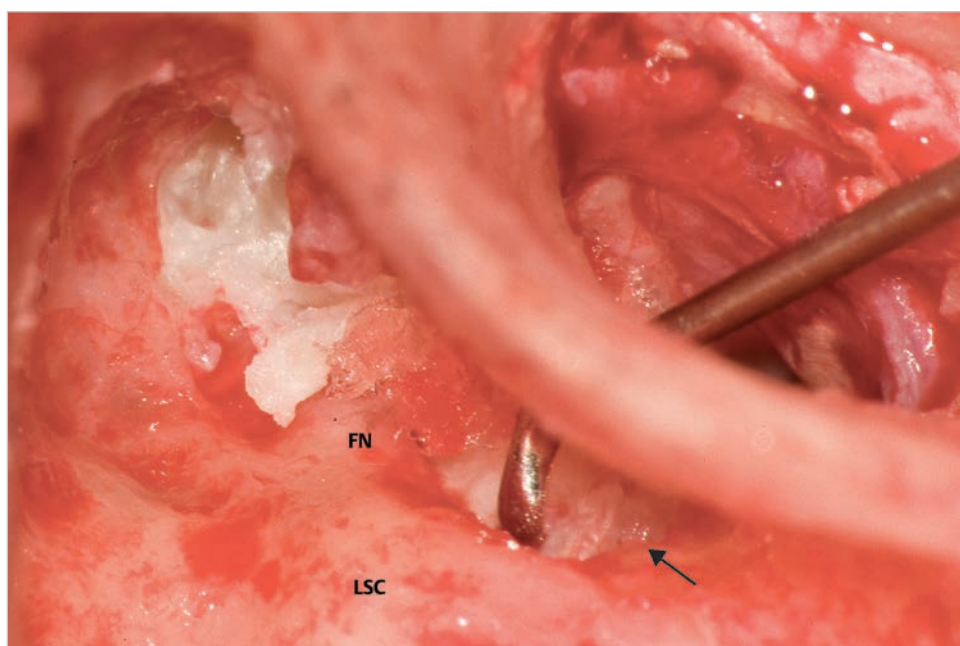


Fig. 8.76 To control cholesteatoma from the mastoid, posterior tympanotomy is carried out (*arrow*). The combined approach introducing a dissector through the meatus is used to see better the area of the stapes. FN, facial nerve; LSC, lateral semicircular canal.



Fig. 8.77 To advance dissection anteriorly, the handle of the malleus is cut.

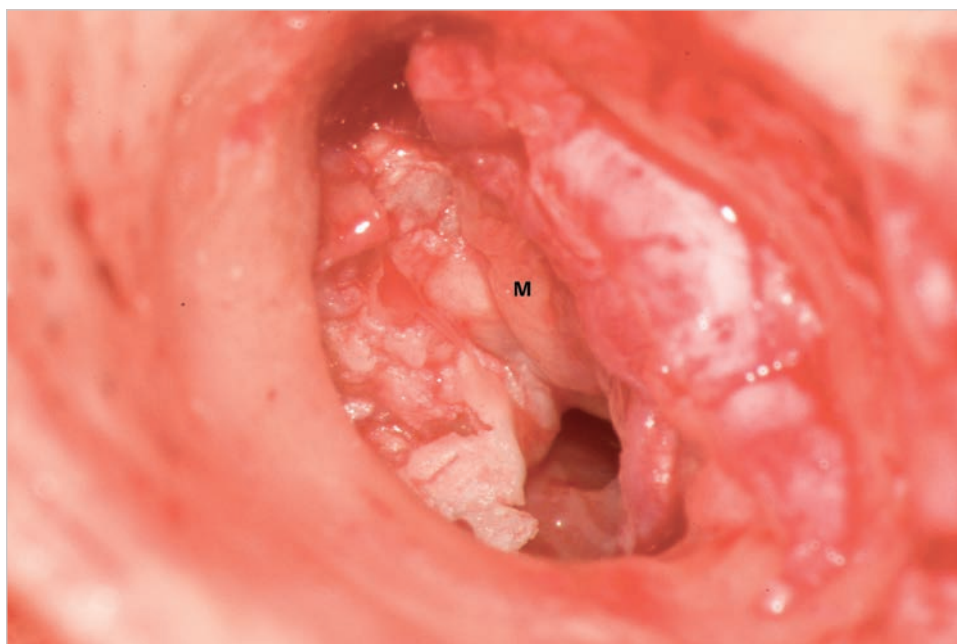


Fig. 8.78 The tympanic membrane is reflected anteriorly with the handle. Access to the anterior part of the tympanic cavity is established. M, handle of the malleus.

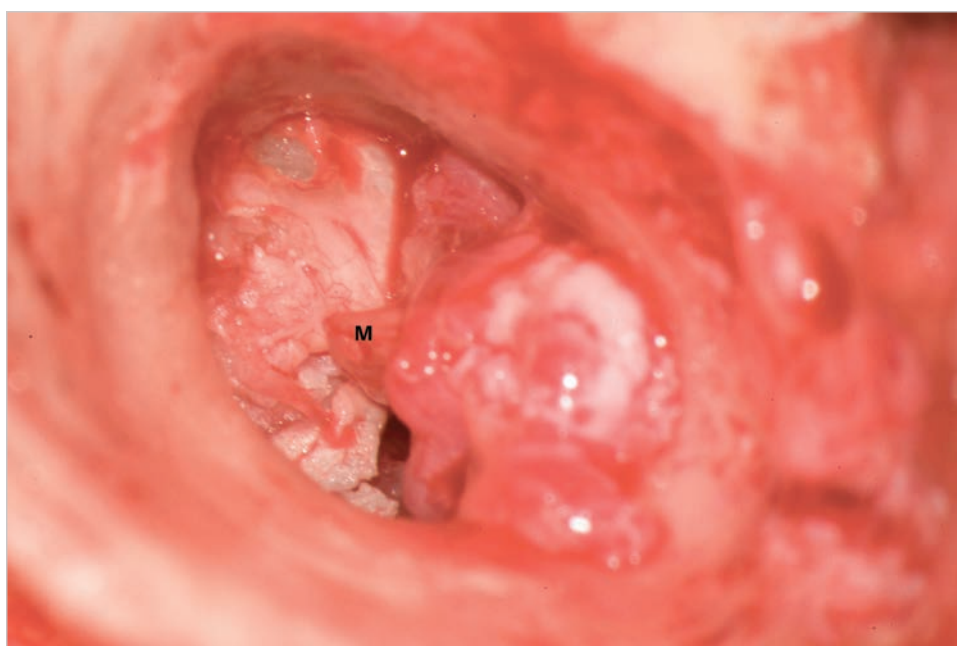


Fig. 8.79 The anterosuperior part of the tympanic membrane is detached from the bony annulus to expose cholesteatoma invaginating into the eustachian tube. M, handle of malleus.



Fig. 8.80 Debulking and careful dissection makes the anterior end of cholesteatoma under control.

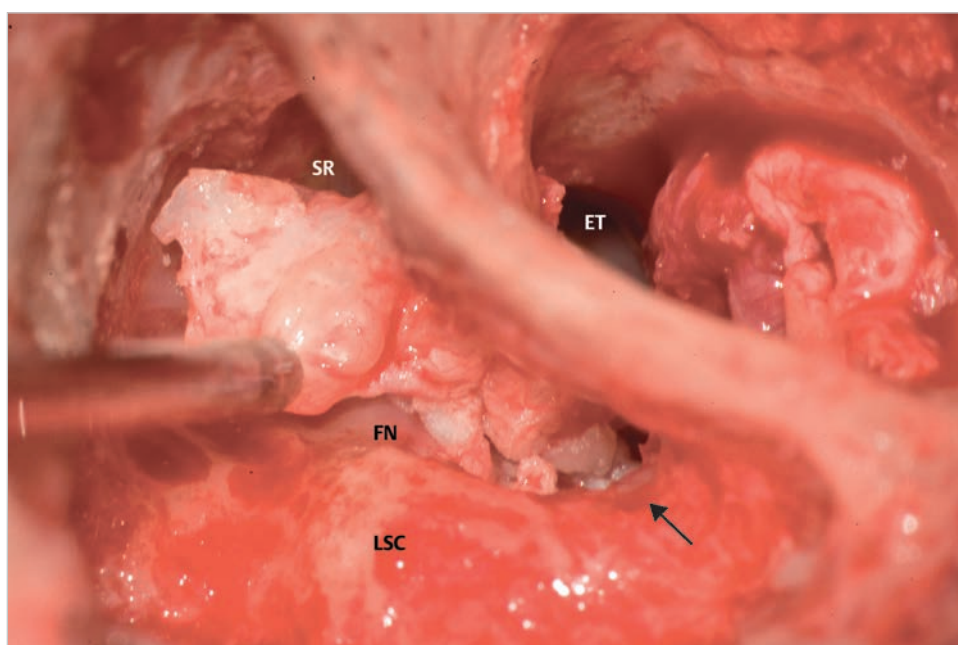


Fig. 8.81 After cutting the tendon of the tensor tympani muscle, the head of the malleus is removed. The cholesteatoma is dissected from the supratubal recess and mastoid. ET, eustachian tube; FN, facial nerve; LSC, lateral semicircular canal; SR, supratubal recess.



Fig. 8.82 The last part of the cholesteatoma left over the area of the tympanic segment of the facial nerve and the stapes is seen.

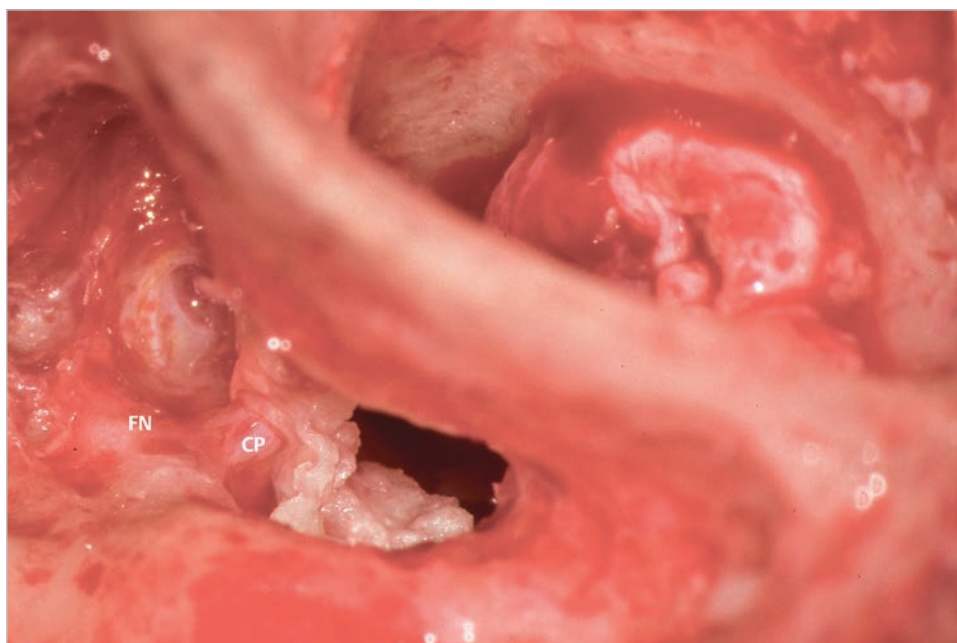


Fig. 8.83 The matrix is dissected from the facial nerve. The matrix still covers the cochleariform process and the area of the stapes. CP, cochleariform process; FN, facial nerve.



Fig. 8.84 The area of the stapes is seen through the posterior tympanotomy. The arrow indicates the head of the stapes. The superior aspect of the stapes is still covered with matrix.

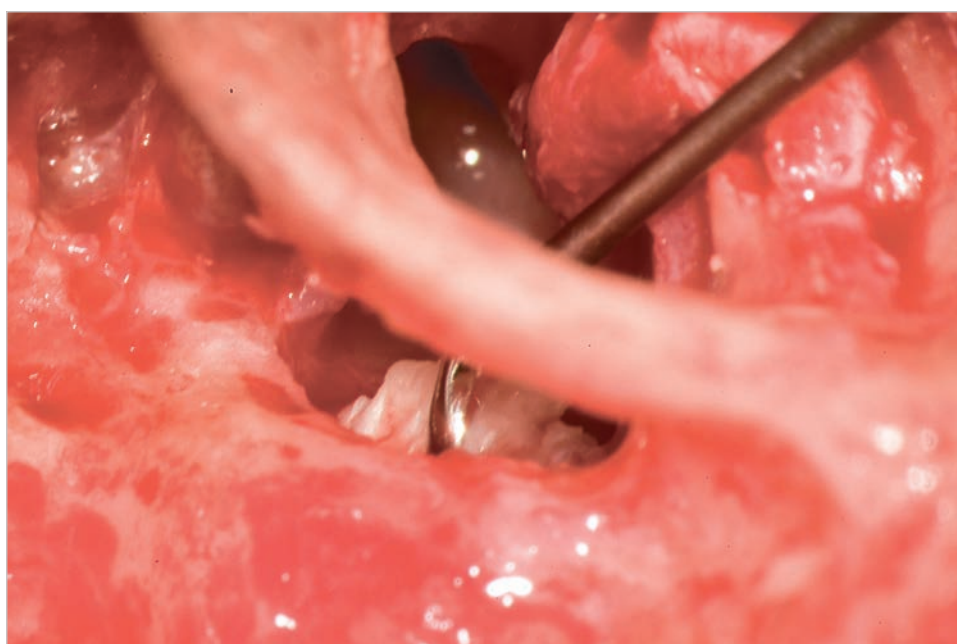


Fig. 8.85 Dissection of the matrix from the stapes is shown.



Fig. 8.86 The final shape of the cavity is shown. Note that infiltrated cells in the tegmen of the mastoid and the antrum and the attic are completely removed.



Fig. 8.87 A Silastic sheeting that covers both the tympanic cavity and the mastoid is introduced.



Fig. 8.88 Both tympanic and mastoid cavities are packed with Gelfoam.

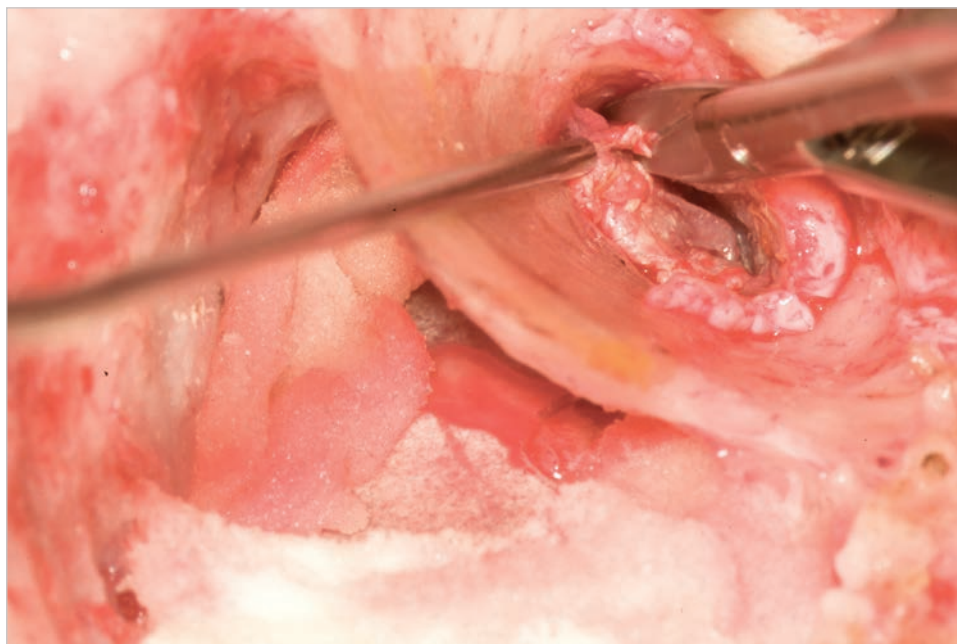


Fig. 8.89 Temporalis fascia is grafted underlay, and a plastic cut is made in the meatal skin.



Fig. 8.90 The tympanomeatal flap is replaced over the fascia.

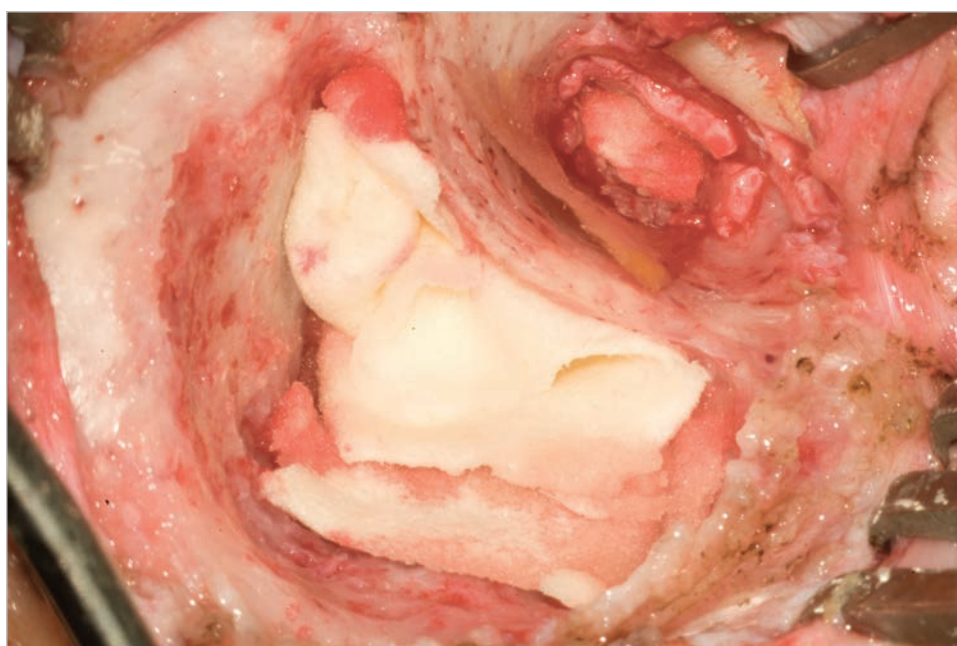


Fig. 8.91 The cavity and the meatus are packed with Gelfoam.

Second Stage of the Same Case

See ▶Fig. 8.92, ▶Fig. 8.93, ▶Fig. 8.94, ▶Fig. 8.95, ▶Fig. 8.96,
▶Fig. 8.97, ▶Fig. 8.98, ▶Fig. 8.99, ▶Fig. 8.100, ▶Fig. 8.101,
▶Fig. 8.102, ▶Fig. 8.103, ▶Fig. 8.104, ▶Fig. 8.105, ▶Fig. 8.106.

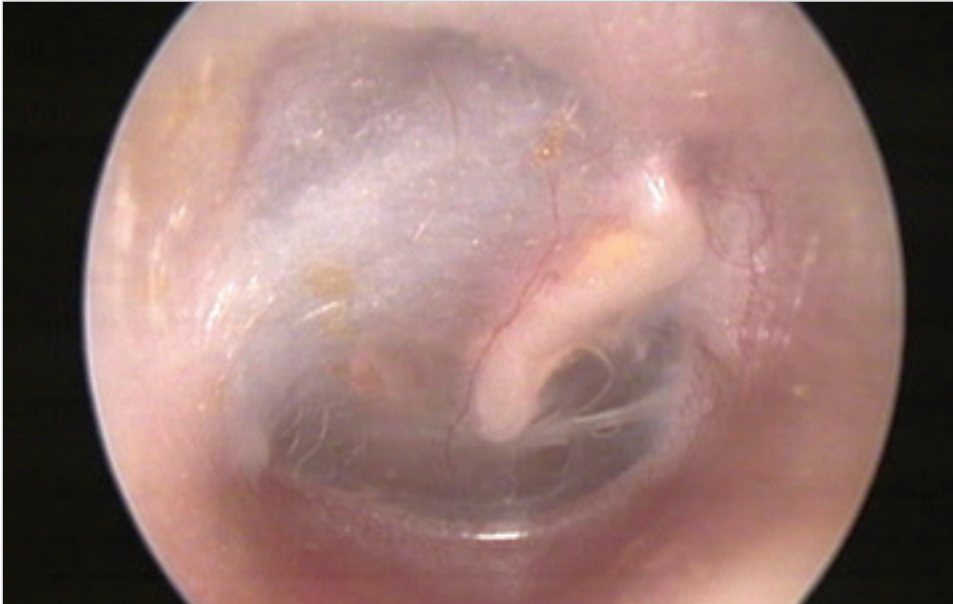


Fig. 8.92 The postoperative otoscopy demonstrated well-epithelized tympanic membrane and the pneumatized tympanic cavity.



Fig. 8.93 Via retroauricular incision, the mastoid is opened. A Silastic sheeting placed in the first stage is seen.

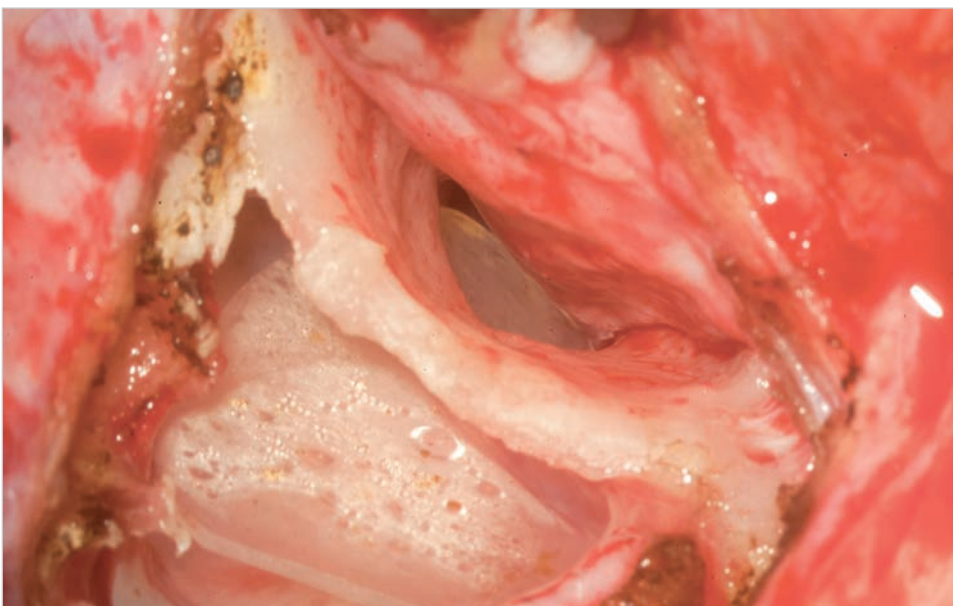


Fig. 8.94 The tympanic cavity is opened to explore the tympanic cavity intensively.

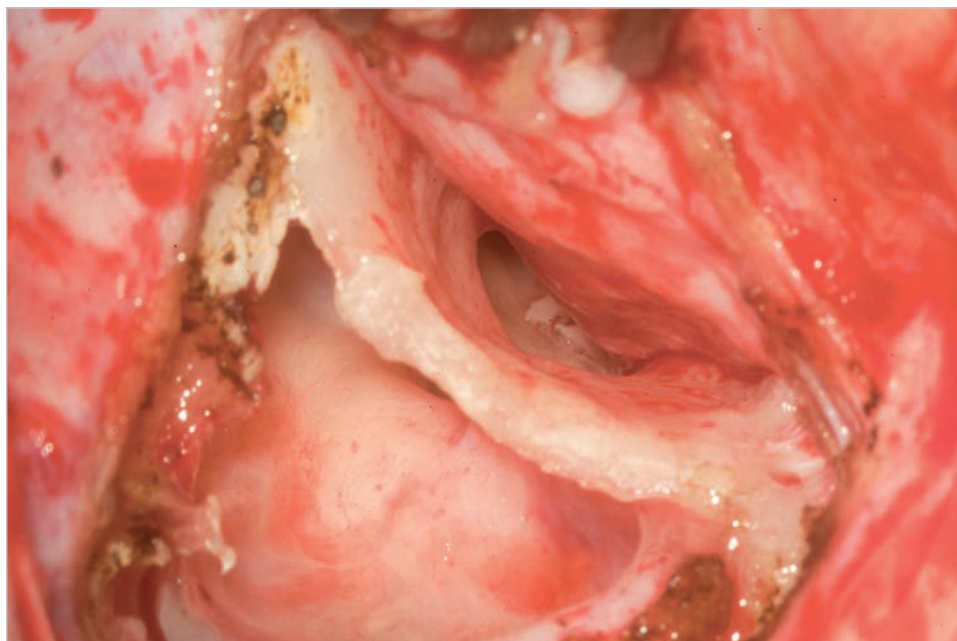


Fig. 8.95 Removal of the Silastic sheeting exposed scar tissue covering the medial face of it.

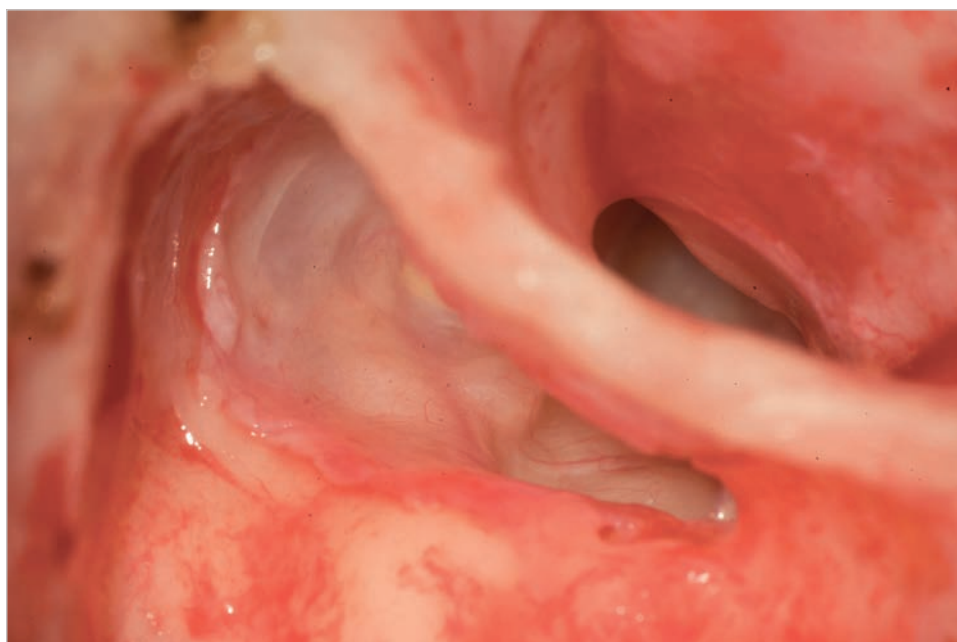


Fig. 8.96 The tympanic cavity is opened to explore the tympanic cavity intensively.

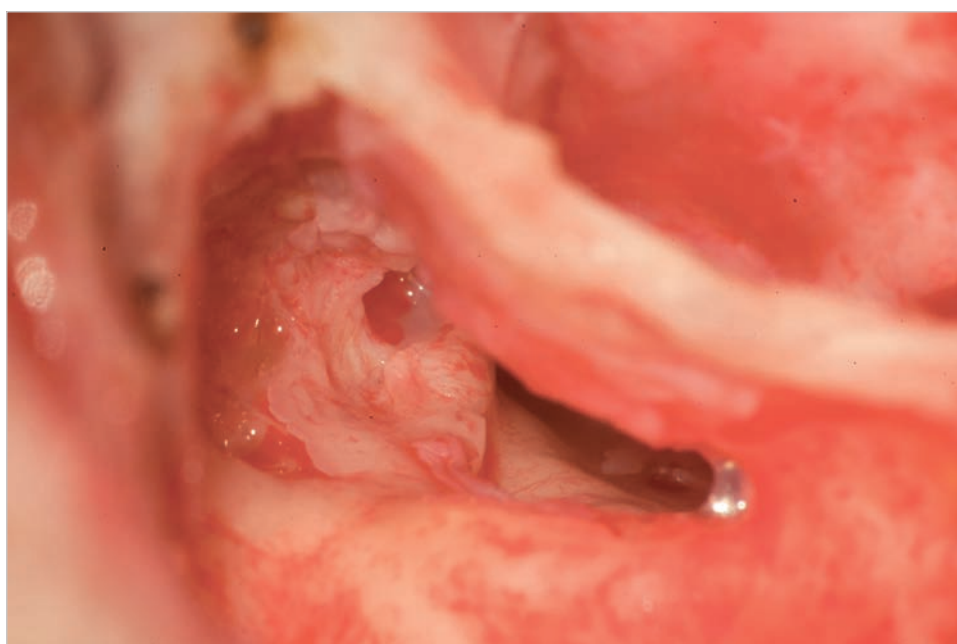


Fig. 8.97 The mesotympanic area is explored through the posterior tympanotomy.



Fig. 8.98 The area of the stapes is explored through the external auditory canal. The posterior meatal skin is not incised to facilitate postoperative healing. The scar tissue covering the oval window should be removed to expose the footplate.

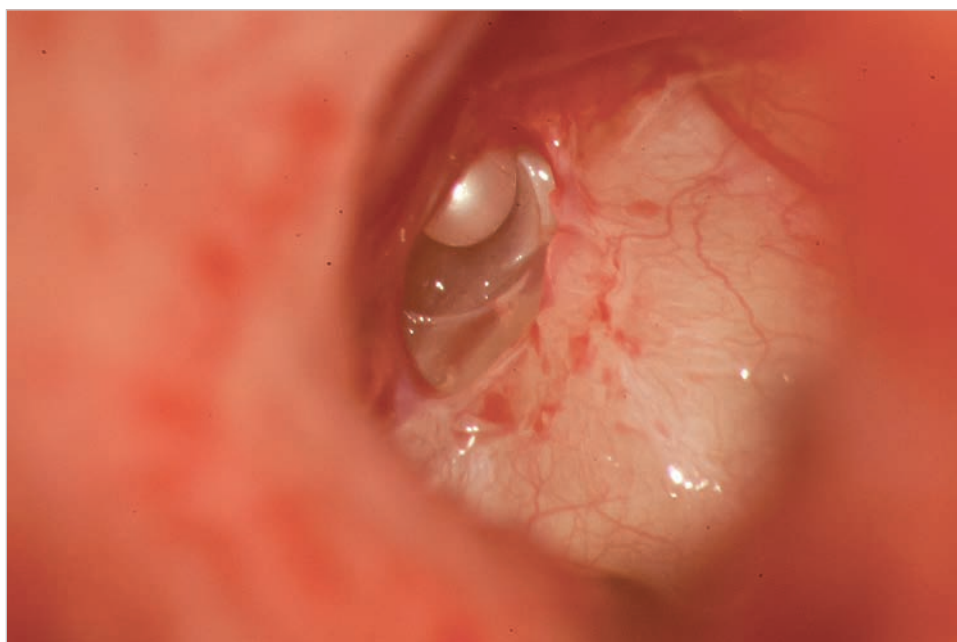


Fig. 8.99 Removal of scar tissue covering the footplate exposed a small residual lesion forming a pearl on the anterior end of the footplate.



Fig. 8.100 Citracal tissue around the oval window is further removed, and the pearl is removed from the footplate. The round window niche is identified inferoposteriorly to the footplate.



Fig. 8.101 A piece of tragal cartilage is harvested to reinforce the tympanic membrane.



Fig. 8.102 An incus is used as a columella over the footplate.

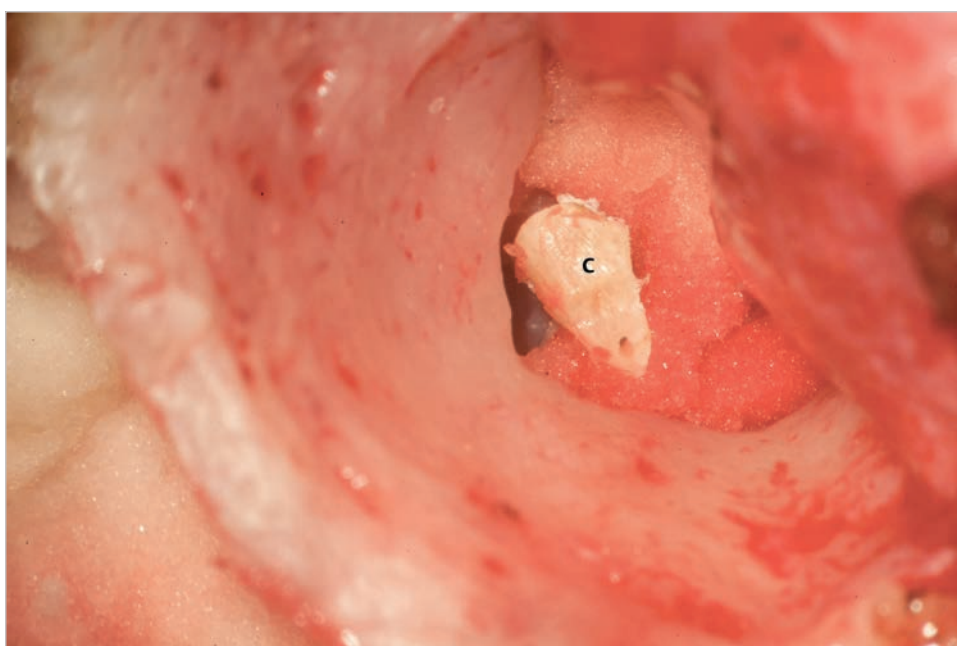


Fig. 8.103 The tympanic cavity is packed with pieces of Gelfoam leaving the area of the footplate unpacked, and the columella is introduced over the footplate. C, columella.

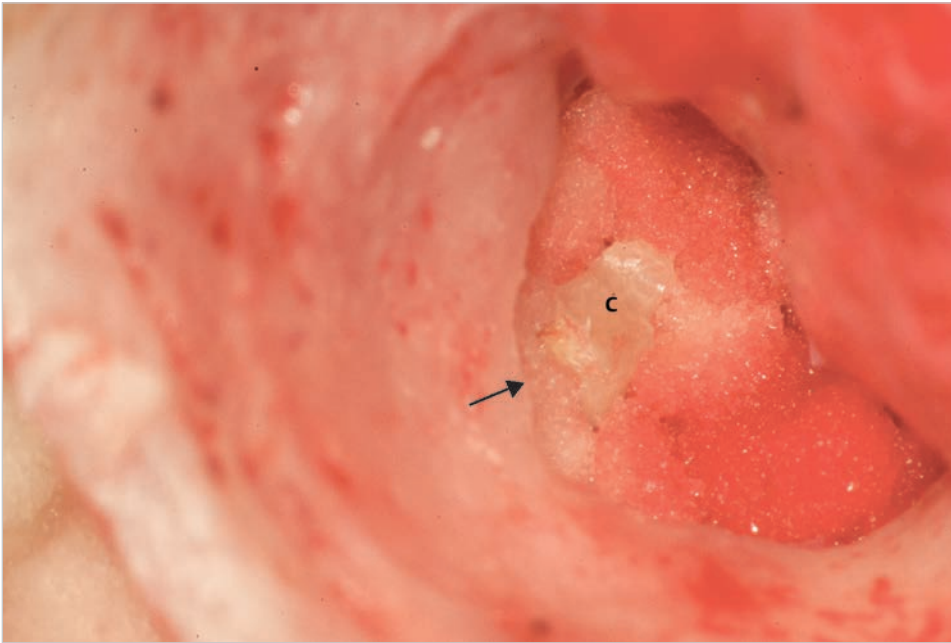


Fig. 8.104 A piece of Gelfoam is placed between the posterior wall and the columella (*arrow*) to prevent adhesion. Since the handle of the malleus is located far anteriorly, decision is made to place the columella simply between the tympanic membrane and the footplate. C, columella.



Fig. 8.105 A piece of cartilage is placed over the columella to reinforce the tympanic membrane. The tympanomeatal flap is replaced over it.

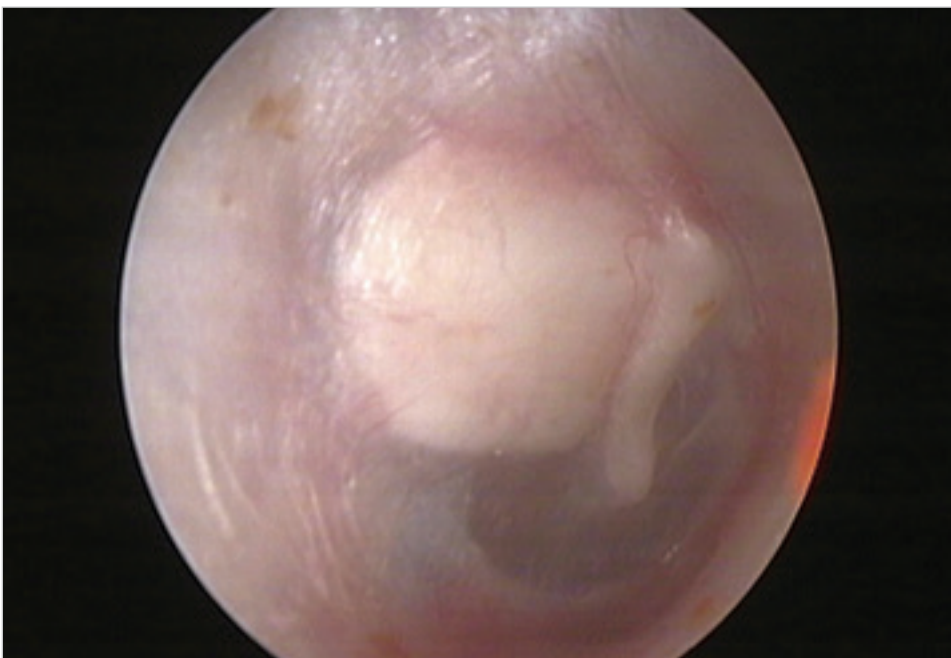


Fig. 8.106 The postoperative otoscopy shows adequate position of the cartilage reinforcing the tympanic membrane.

Case 8.5 (Left Ear)

See ▶ Fig. 8.107, ▶ Fig. 8.108, ▶ Fig. 8.109, ▶ Fig. 8.110, ▶ Fig. 8.111, ▶ Fig. 8.112, ▶ Fig. 8.113, ▶ Fig. 8.114, ▶ Fig. 8.115.

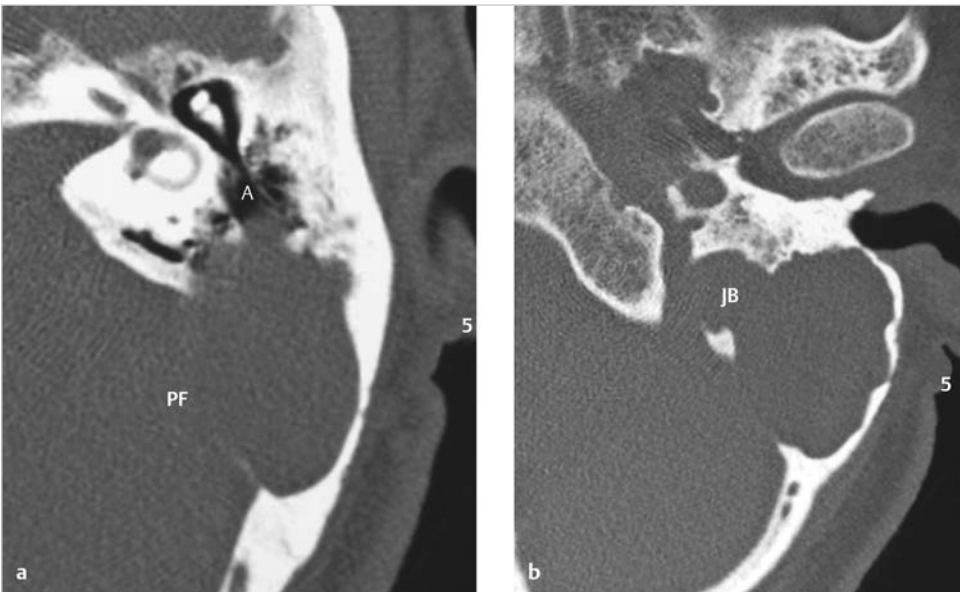


Fig. 8.107 A case of congenital cholesteatoma in the mastoid is shown. The axial CT at the level of the lateral semicircular canal (a) shows presence of soft tissue in the mastoid with expansive growth eroding and pushing the posterior fossa. The mass partially infiltrates the antrum, but no pathology is found in the attic. The caudal slice (b) shows large bony erosion in the jugular bulb. A, antrum; JB, jugular bulb; PF, posterior fossa.

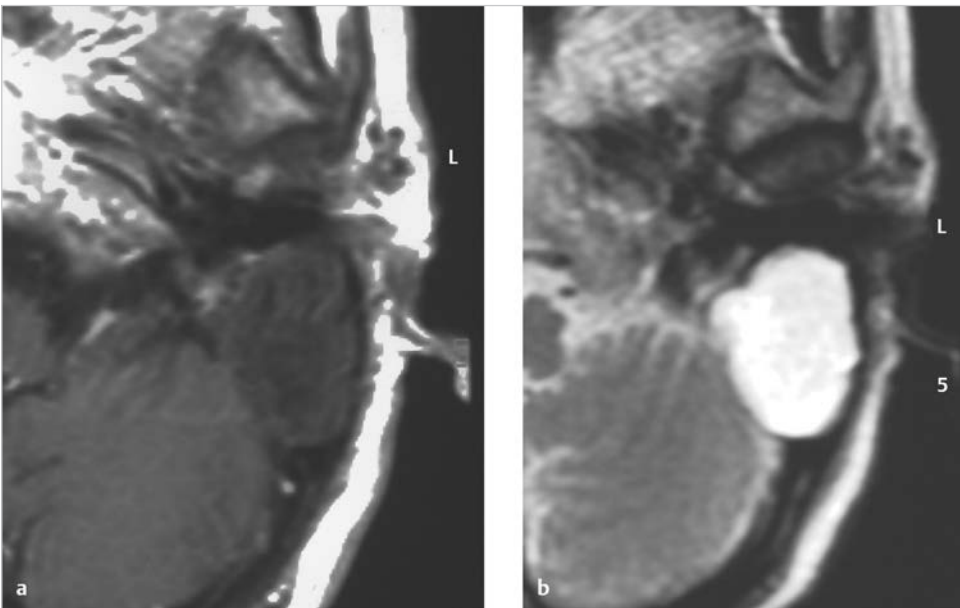


Fig. 8.108 The lesion shows low signal in T1-weighted image (a) of MRI, and high in T2-weighted image (b), corresponding to cholesteatoma.

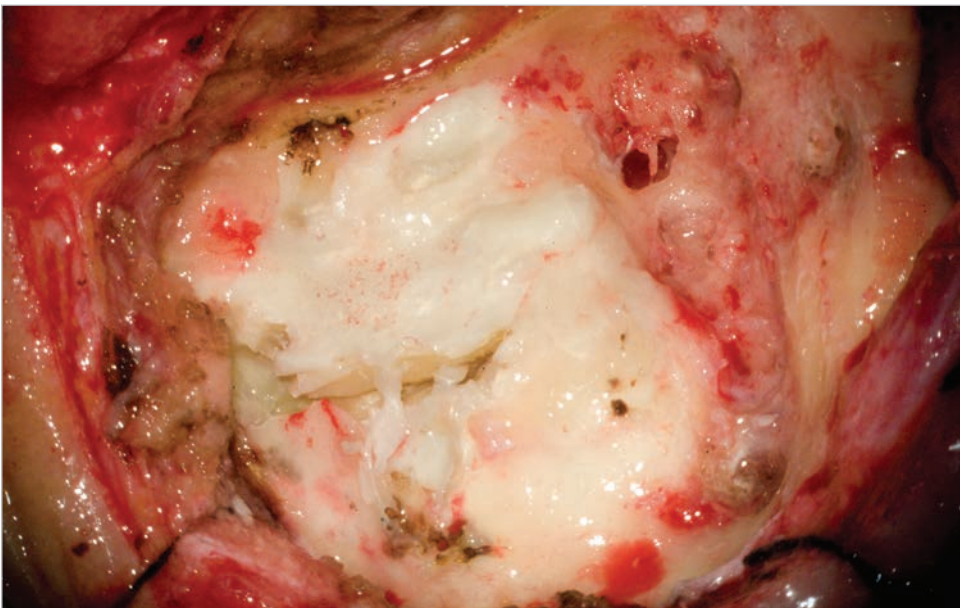


Fig. 8.109 To fit large operating field expected, a C-shaped incision with stitches to hold the musculoperiosteal layer is used. A cortical mastoidectomy revealed very large cholesteatoma occupying the mastoid inferiorly to the antrum.

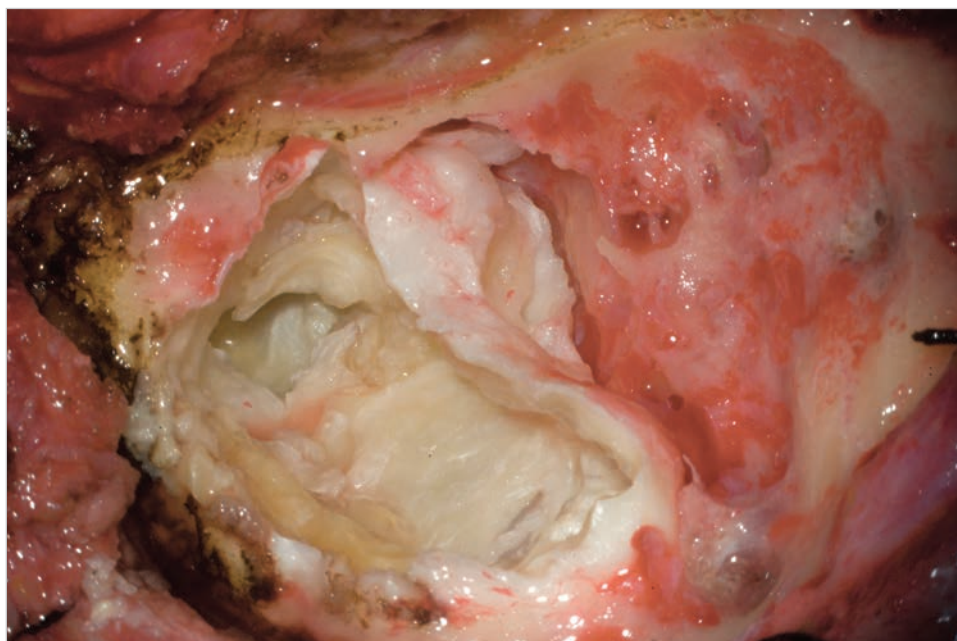


Fig. 8.110 After reducing debris, the cholesteatoma is detached from the labyrinthine block, and the dissection is advanced inferiorly.

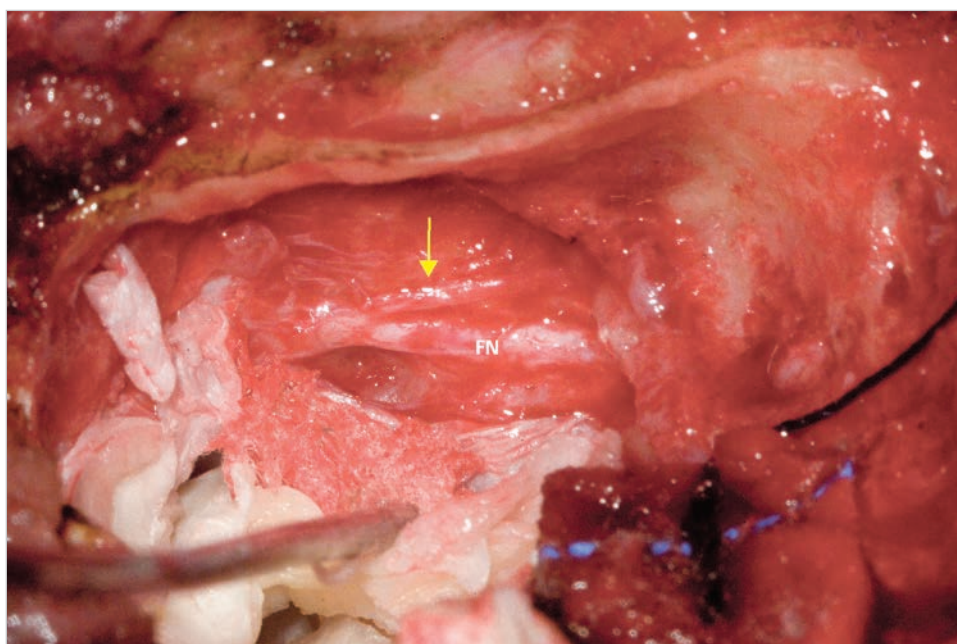


Fig. 8.111 The facial nerve and the chorda tympani nerve (arrow) branching from it are exposed in the anterior wall. FN, facial nerve.

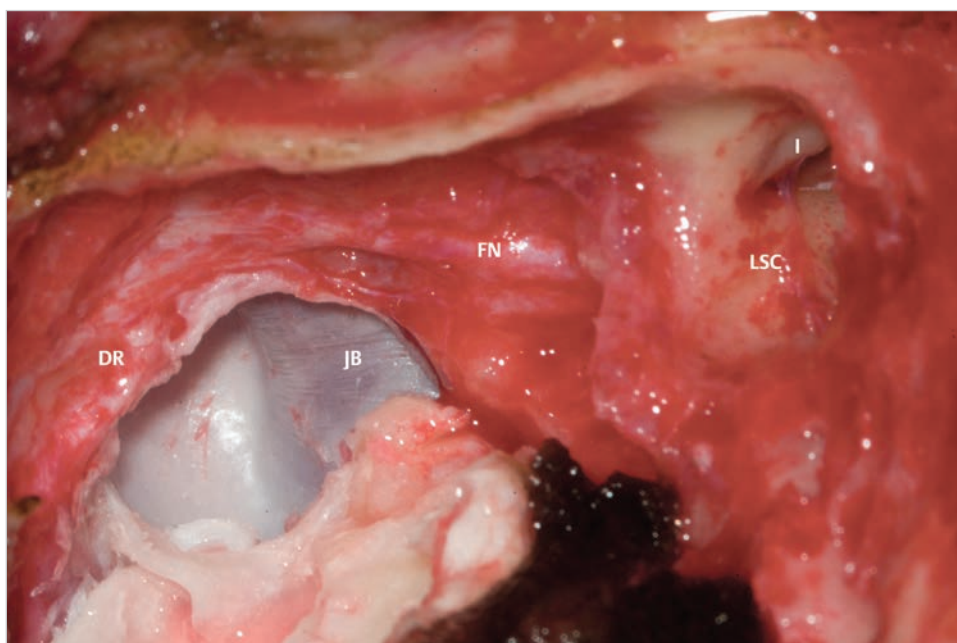


Fig. 8.112 Medially to the facial nerve, a very large jugular bulb is identified under the matrix. DR, digastric ridge; FN, facial nerve; I, incus; JB, jugular bulb; LSC, lateral semicircular canal.

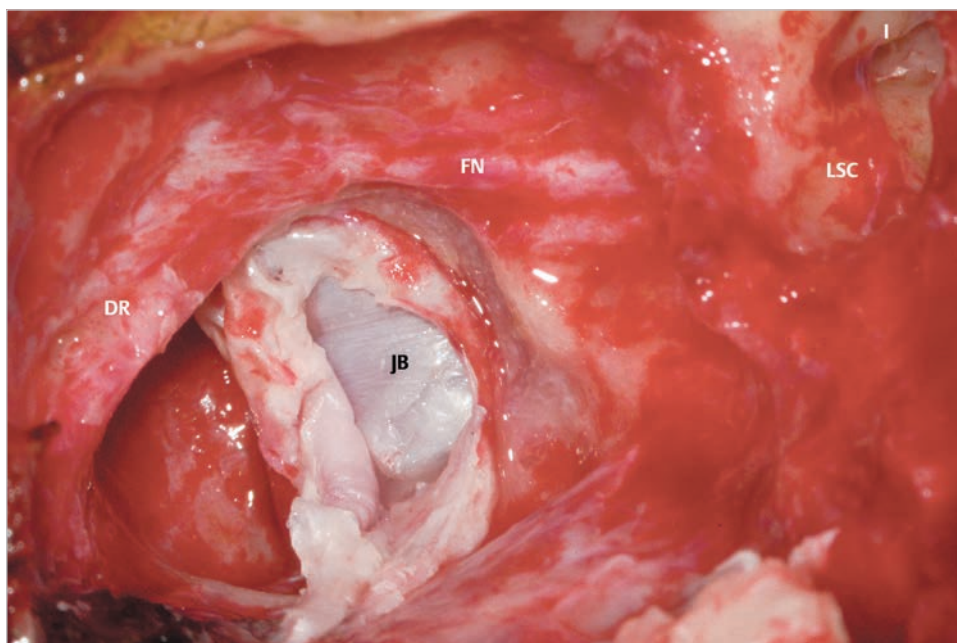


Fig. 8.113 Trial to remove the matrix covering the jugular bulb is left until the last moment of dissection to provide against accidental massive bleeding. DR, digastric ridge; FN, facial nerve; I, incus; JB, jugular bulb; LSC, lateral semicircular canal.

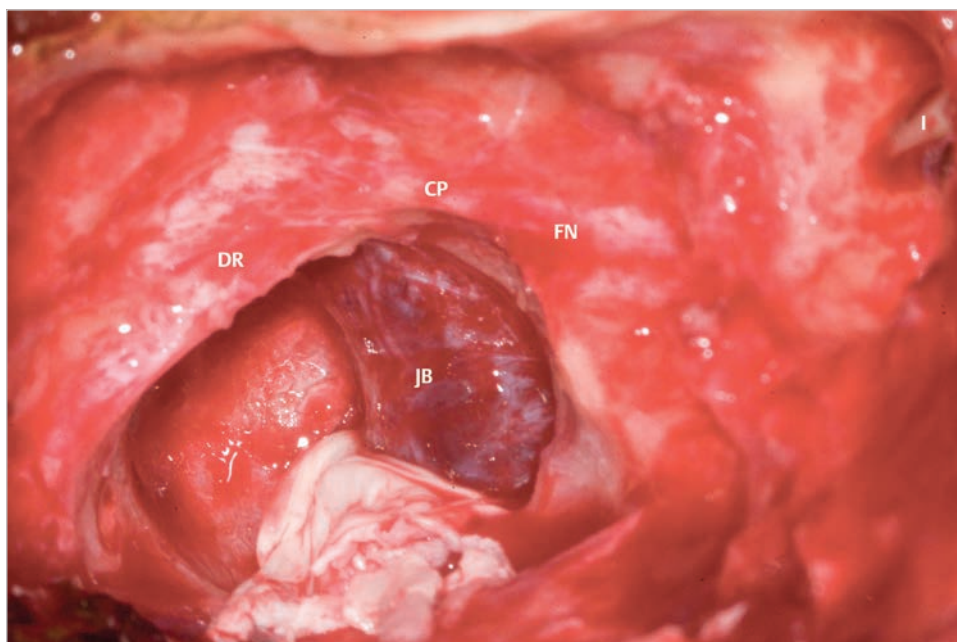


Fig. 8.114 Removal of the matrix is on the way. Great care should be taken in this procedure since the wall of the jugular bulb is extremely fragile. CP, cochleariform process; DR, digastric ridge; FN, facial nerve; I, incus; JB, jugular bulb.

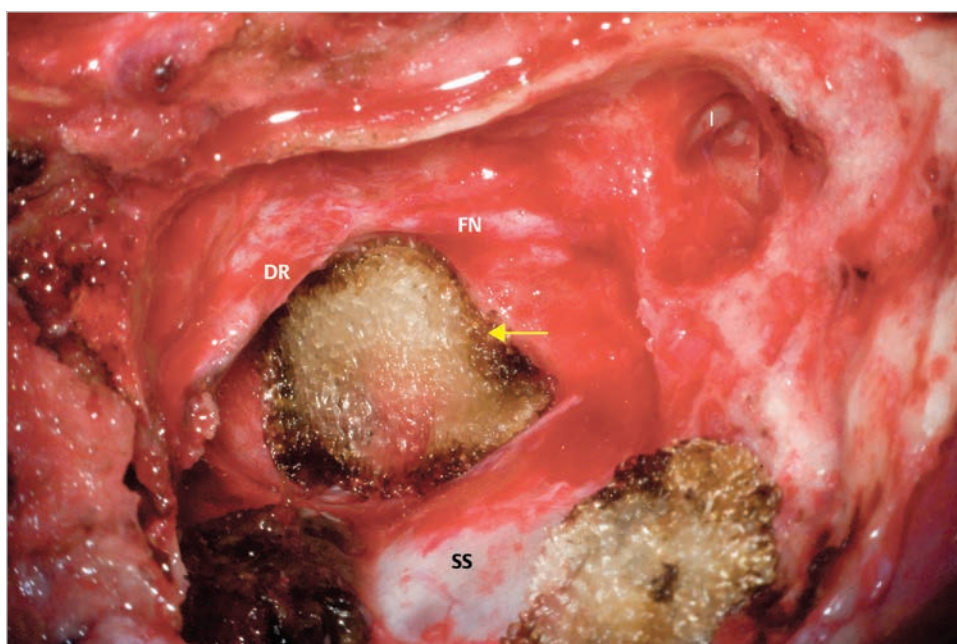


Fig. 8.115 The final shape of the cavity is shown. The area of the jugular bulb is covered with Surgicel (arrow) to stop bleeding. DR, digastric ridge; FN, facial nerve; I, incus; SS, sigmoid sinus.

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9 Cholesteatoma of the External Auditory Canal

Cholesteatoma of the external auditory canal is a rare entity, comprising 1 out of 1,000 cases of all otologic patients. A typical appearance is accumulated debris with bone erosion covered by inflamed skin with spotty exposure of necrotic bone. The patient usually suffered from repetitive otorrhea with dull pain in the affected ear. The lesion usually affects the inferior wall of the external auditory canal, that is, the tympanic bone, and progression of the disease involves posterior wall to open the mastoid, and anterior wall to expose the capsule of the temporomandibular joint. In advanced cases, the mastoid may be filled with debris similar to middle ear cholesteatoma. Pathogenesis of this primary idiopathic lesion is not known. It is speculated that ischemic process of the affected region plays key role, and factors that impair microcirculation of the external auditory canal, such as hemodialysis, diabetes mellitus, smoking habit, and irradiation of the head or the epipharynx, have been reported to increase incidence. Early lesions can be managed conservatively, but in advanced lesions, surgical correction is required. The eroded bone is drilled and covered with multiple layers using materials such as bone paste, cartilage, fascia, and soft tissue flaps. The mastoid should be either opened applying canal wall down technique or closed by reconstruction of the posterior wall.

Secondary cholesteatoma in the external auditory canal may arise after tympanoplasty due to various reasons. An involved vascular strip in the lateral part of the meatus, reabsorption of the posterior canal wall that is thinned too much in canal wall up technique, incorrect arrangement of the skin flap that allows it falling down to the cavity, and an excessively lowered posterior canal wall can be the cause of iatrogenic cholesteatoma in this location. The secondary cholesteatoma can also be formed medially to the stenotic lesions in the external auditory canal. Iatrogenic stenosis after tympanoplasty, congenital anomaly, exostosis, fibrous dysplasia of the temporal bone, temporal bone fracture, and scar formation after overuse of cotton swabs can be the cause of such stenosis. Accumulated debris medially to the stenosis causes destructive process in the external auditory canal. Once such lesion is inflamed, the stenosis usually gets narrower, and severe pain with facilitated destructive process may compel an early surgery.

Case 9.1 (Right Ear)

See ► Fig. 9.1, ► Fig. 9.2, ► Fig. 9.3, ► Fig. 9.4, ► Fig. 9.5, ► Fig. 9.6, ► Fig. 9.7, ► Fig. 9.8, ► Fig. 9.9, ► Fig. 9.10.

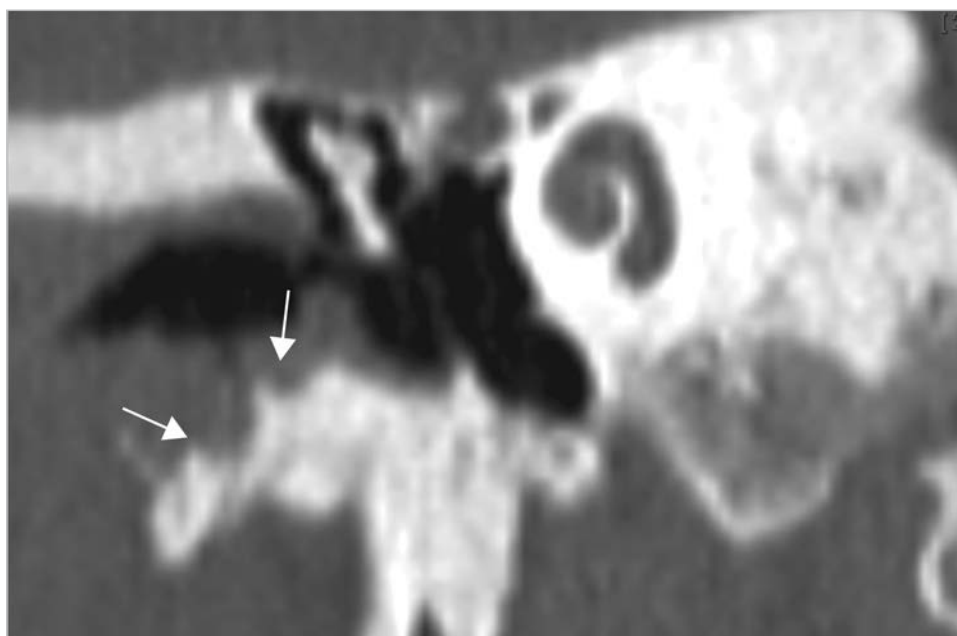


Fig. 9.1 A case of cholesteatoma in the external auditory canal. The coronal CT shows heavy erosion of the tympanic bone (arrows).

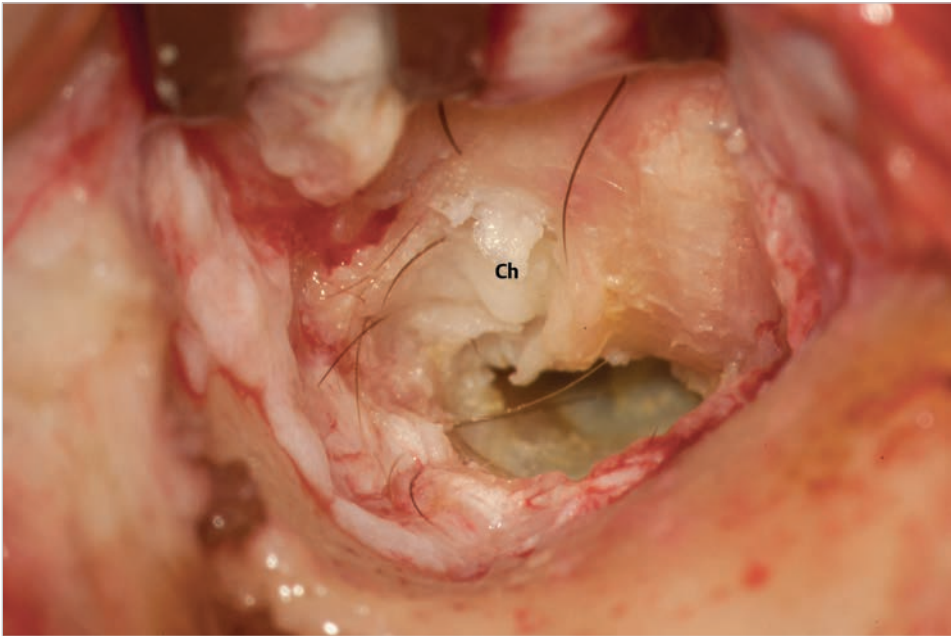


Fig. 9.2 The meatus is exposed through a retroauricular incision. Cholesteatoma of the external auditory canal in the anterosuperior wall corresponds to a disruption of the meatal skin with erosion of bone filled with debris. Ch, cholesteatoma.

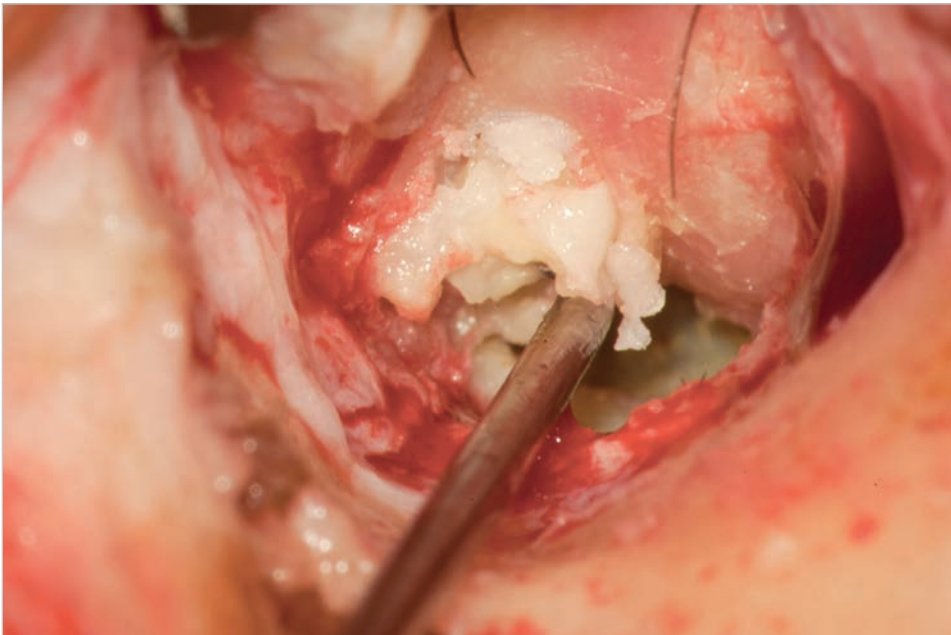


Fig. 9.3 The debris filling the cholesteatoma is evacuated.

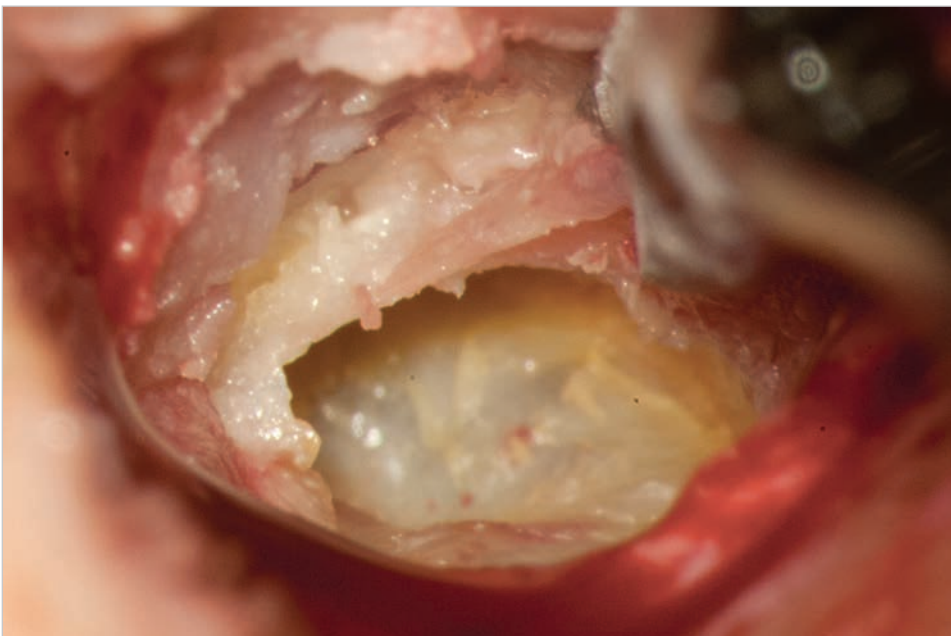


Fig. 9.4 The meatal skin covering cholesteatoma is opened with scissors to further expose bone erosion in the anterior wall.

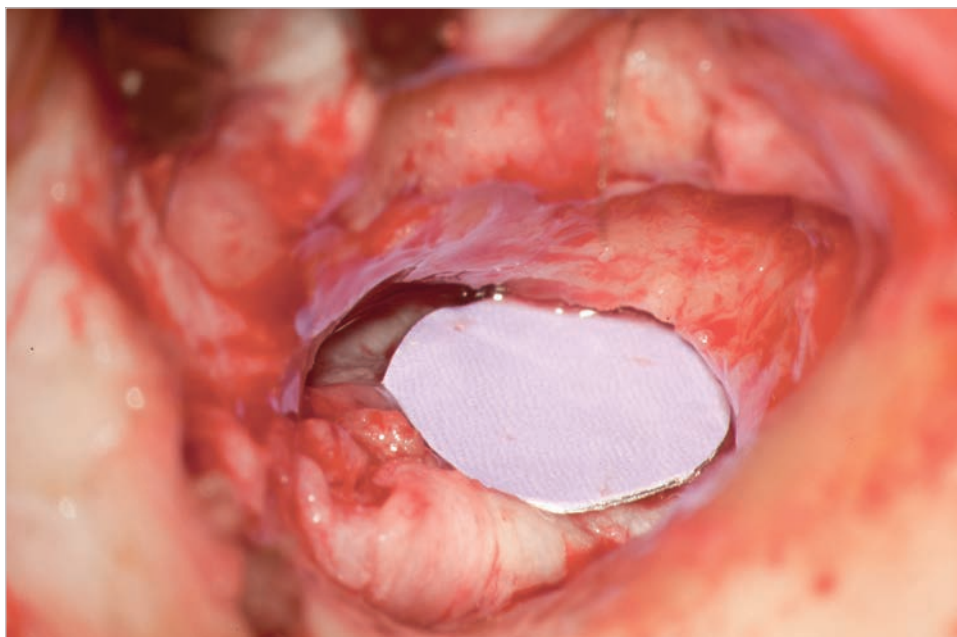


Fig. 9.5 The matrix of the cholesteatoma covering bone erosion is removed, and healthy part of the meatal skin reflected medially is protected with aluminum sheeting.



Fig. 9.6 The anterior and inferior walls are drilled until reaching healthy bone.

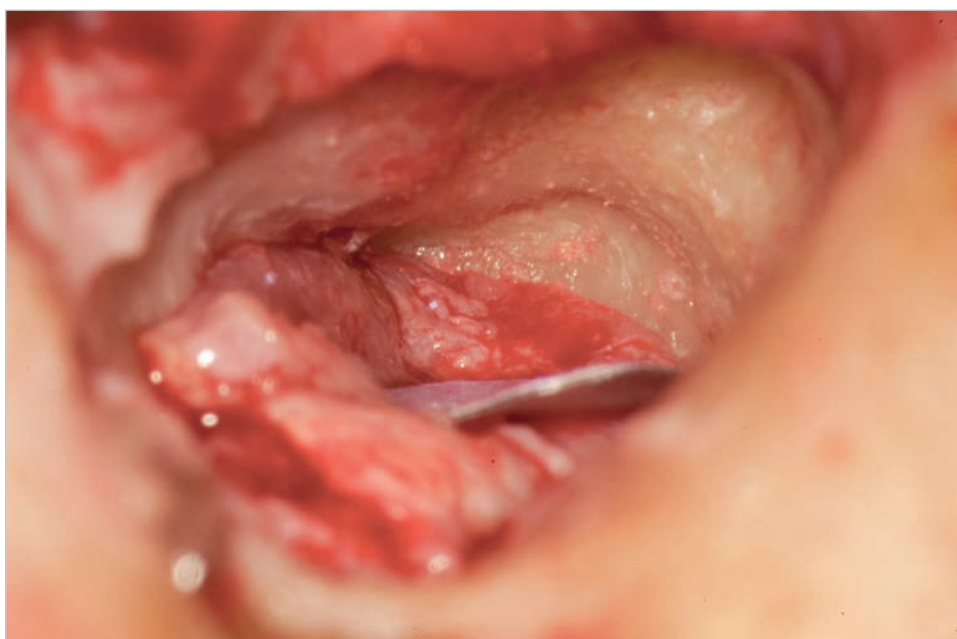


Fig. 9.7 After reaching healthy bone, the area should be smoothed.

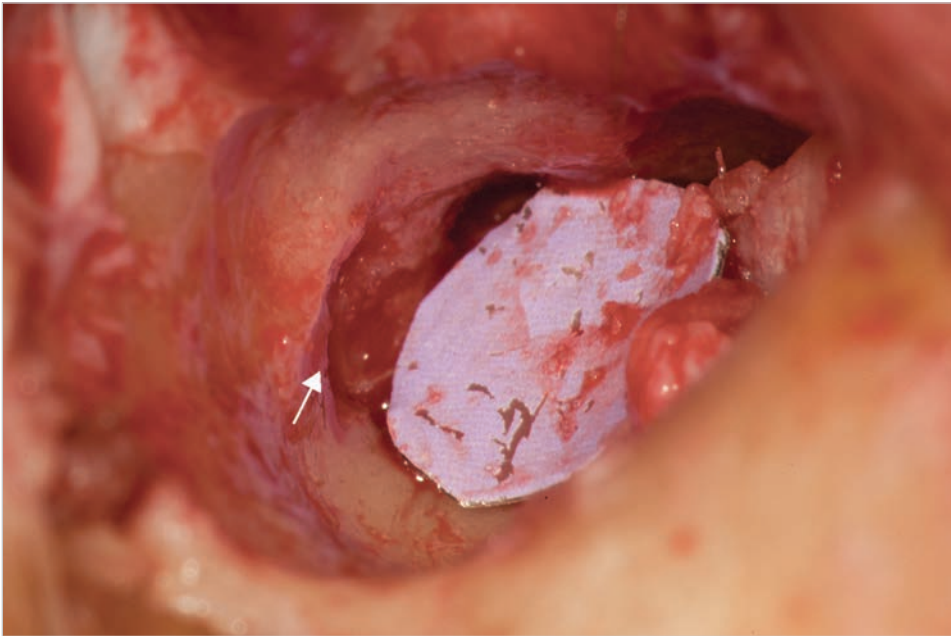


Fig. 9.8 The bone erosion in the anterosuperior wall (*arrow*) should also be drilled.

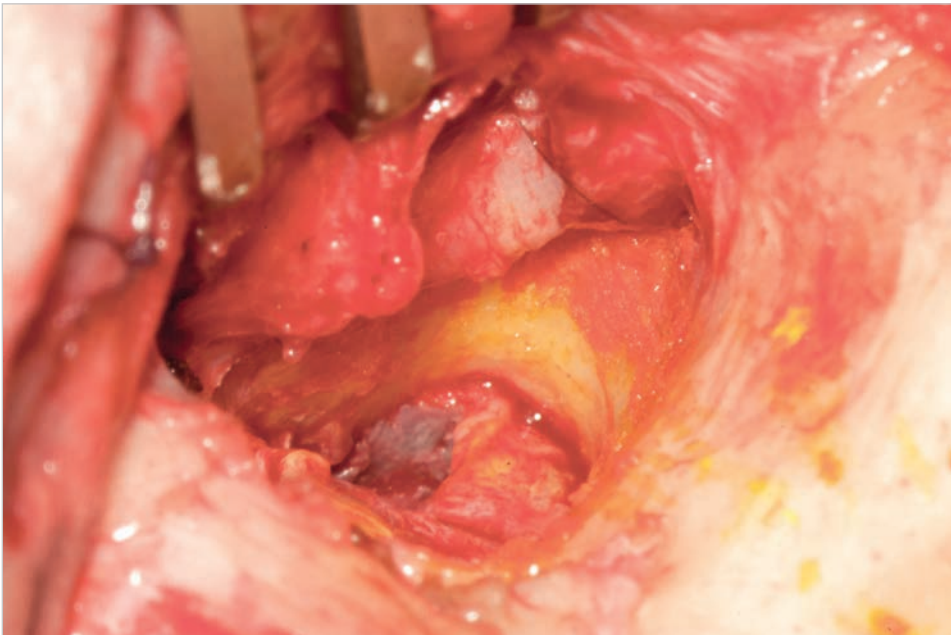


Fig. 9.9 The dip formed after the drilling is obliterated with bone paste.

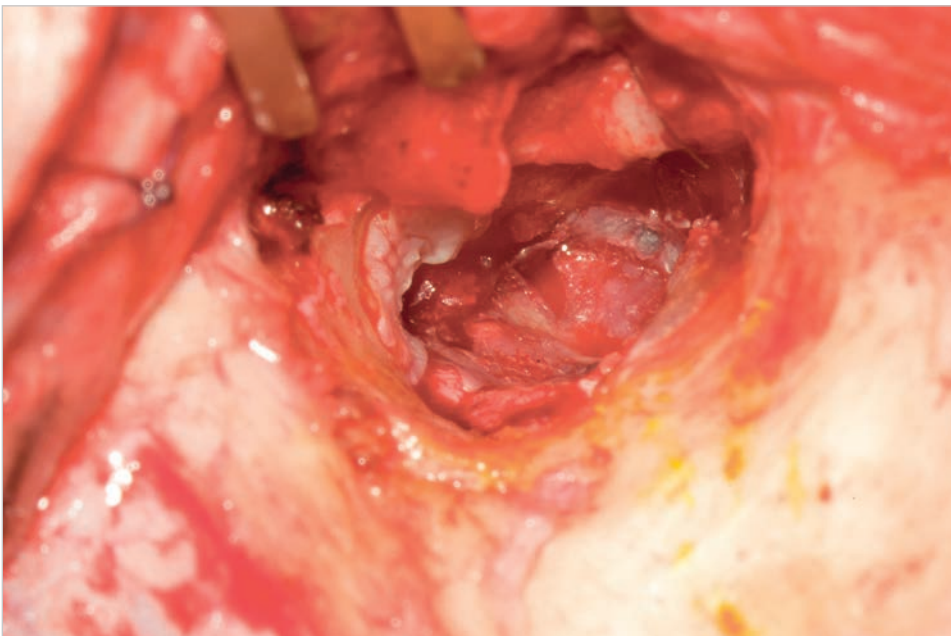


Fig. 9.10 The bone paste is covered with temporalis fascia, and the tympanomeatal flap is replaced. The meatus is packed with Gelfoam.

Case 9.2 (Left Ear)

See ► Fig. 9.11, ► Fig. 9.12, ► Fig. 9.13, ► Fig. 9.14, ► Fig. 9.15, ► Fig. 9.16, ► Fig. 9.17, ► Fig. 9.18, ► Fig. 9.19, ► Fig. 9.20, ► Fig. 9.21, ► Fig. 9.22, ► Fig. 9.23, ► Fig. 9.24, ► Fig. 9.25.



Fig. 9.11 A case of cholesteatoma in the external auditory canal. The otoscopy shows formation of granulation tissue and accumulation of debris in the posterior and inferior walls close to the tympanic membrane with erosion of underlying bone.

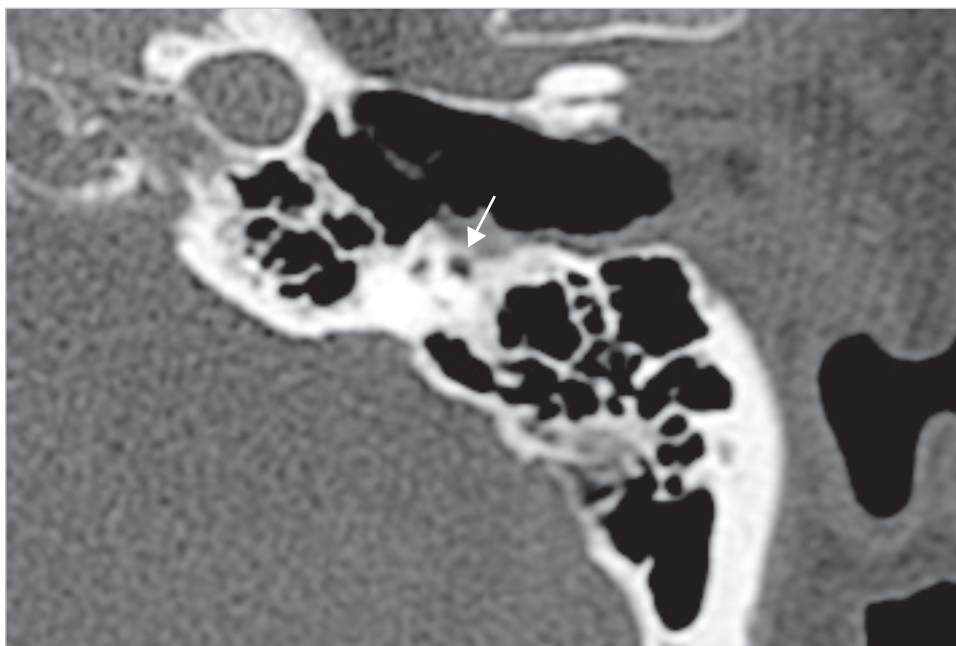


Fig. 9.12 The preoperative axial CT shows bone erosion in the posterior wall to reaching the area of the facial nerve (*arrow*).

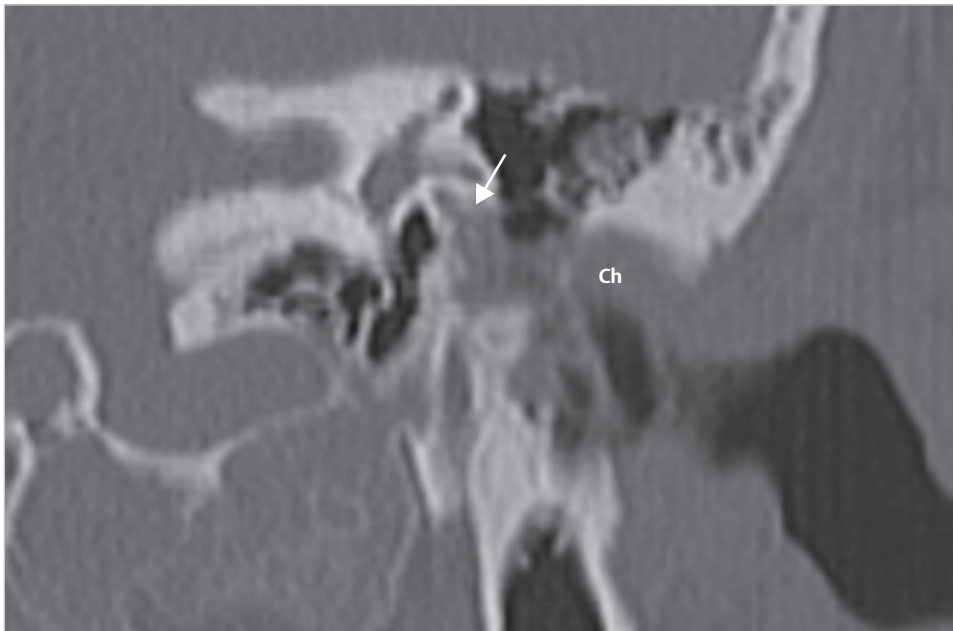


Fig. 9.13 The coronal CT indicates that the cholesteatoma penetrates the posterior wall to open the mastoid air cells. Erosion of the fallopian canal is also demonstrated. Ch, cholesteatoma.

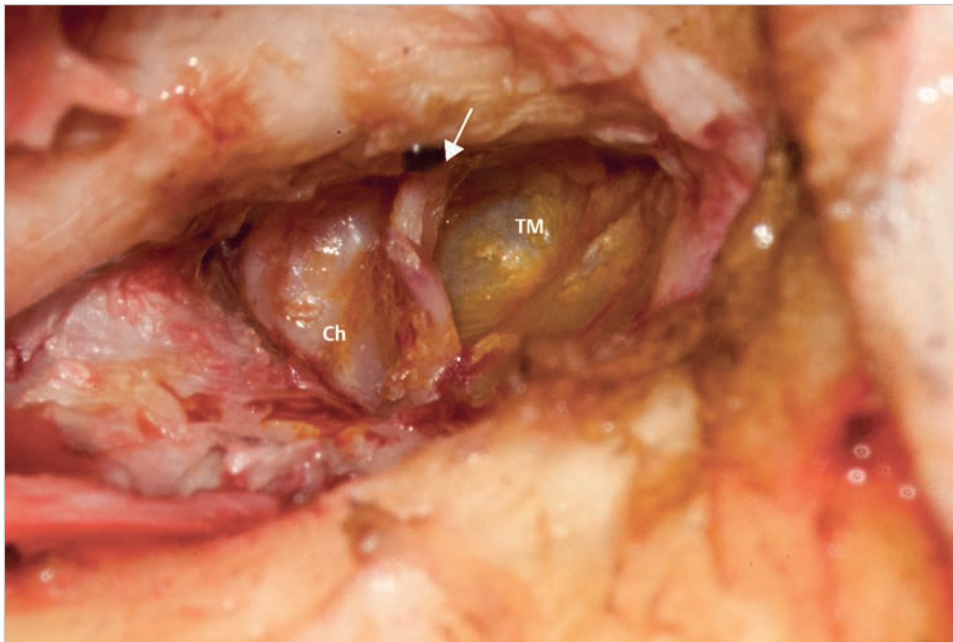


Fig. 9.14 The meatus is entered through a retroauricular incision. A bone erosion just inferior to the tympanic membrane forms a fold (arrow) arising from the fibrous annulus. Ch, cholesteatoma; TM, tympanic membrane.

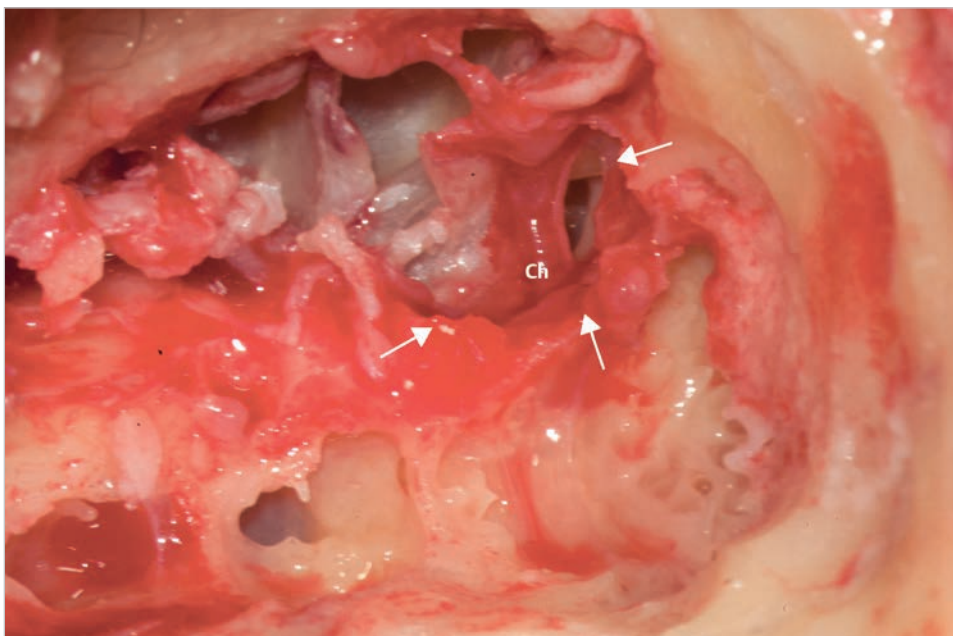


Fig. 9.15 A canal wall down mastoidectomy is carried out to expose the posterior face of cholesteatoma. Note extensive erosion of the posterior wall (arrows). Ch, cholesteatoma.

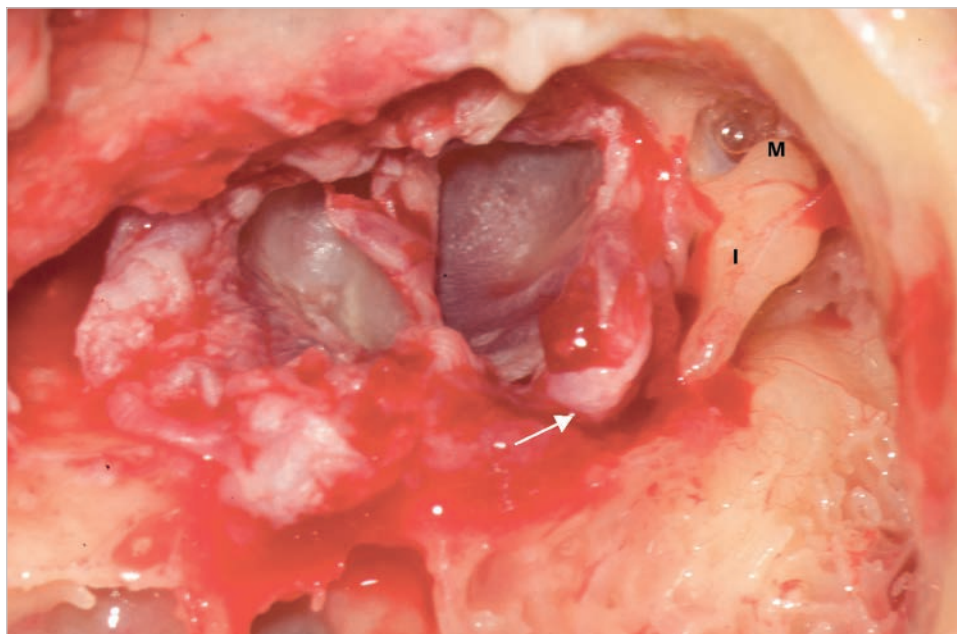


Fig. 9.16 The matrix covering the area of the facial nerve is shown (*arrow*). I, incus; M, malleus.

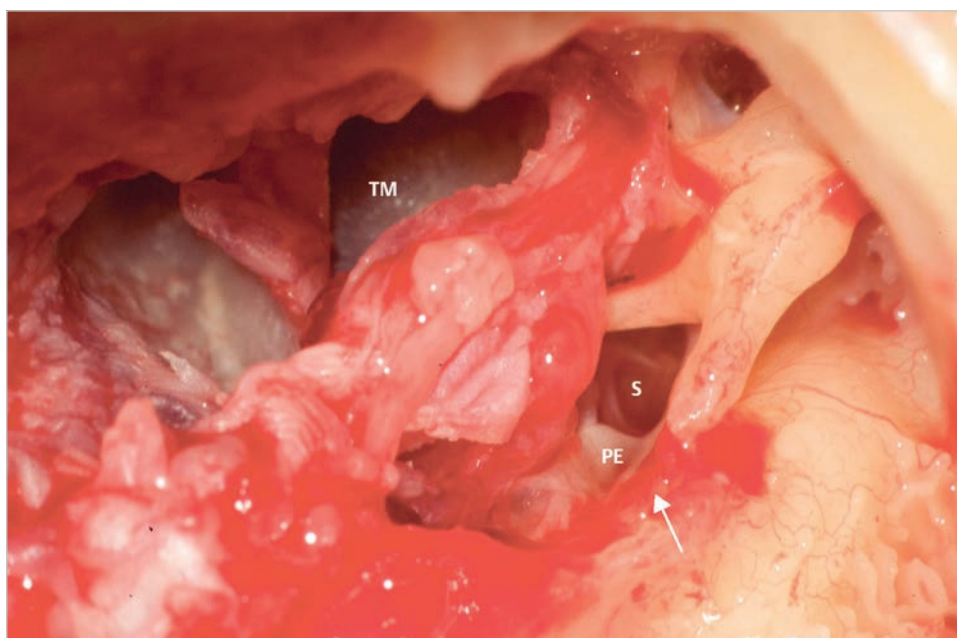


Fig. 9.17 The matrix of cholesteatoma with granulation tissue is detached from the facial nerve (*arrow*). PE, pyramidal eminence; S, stapes; TM, tympanic membrane.

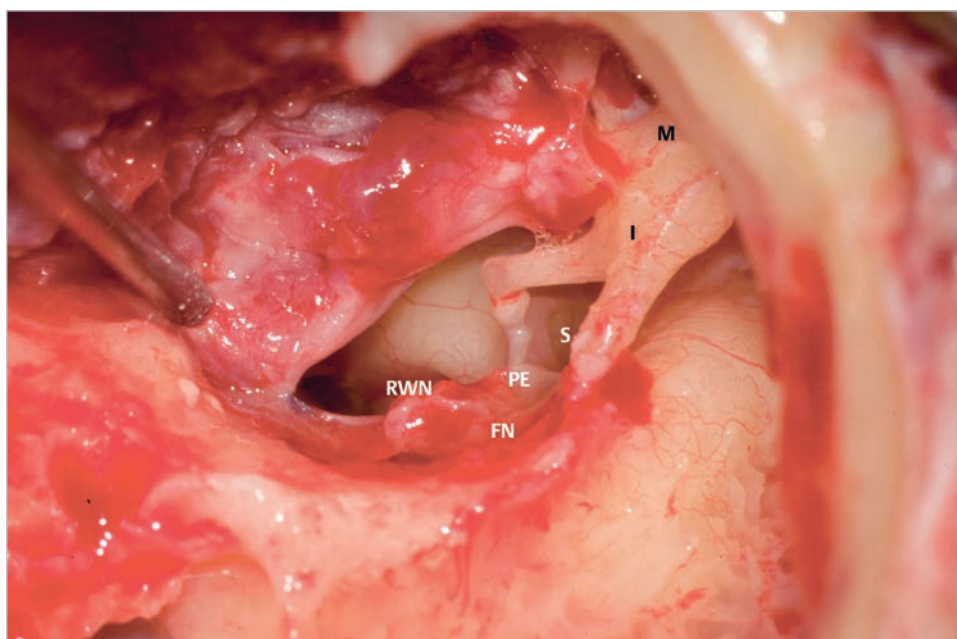


Fig. 9.18 The tympanic membrane is reflected anteriorly together with the matrix of cholesteatoma. The bone erosion in the posterior meatal wall is drilled, and the tympanic cavity is fully opened. FN, facial nerve; I, incus; M, malleus; PE, pyramidal eminence; RWN, round window niche; S, stapes; TM, tympanic membrane.

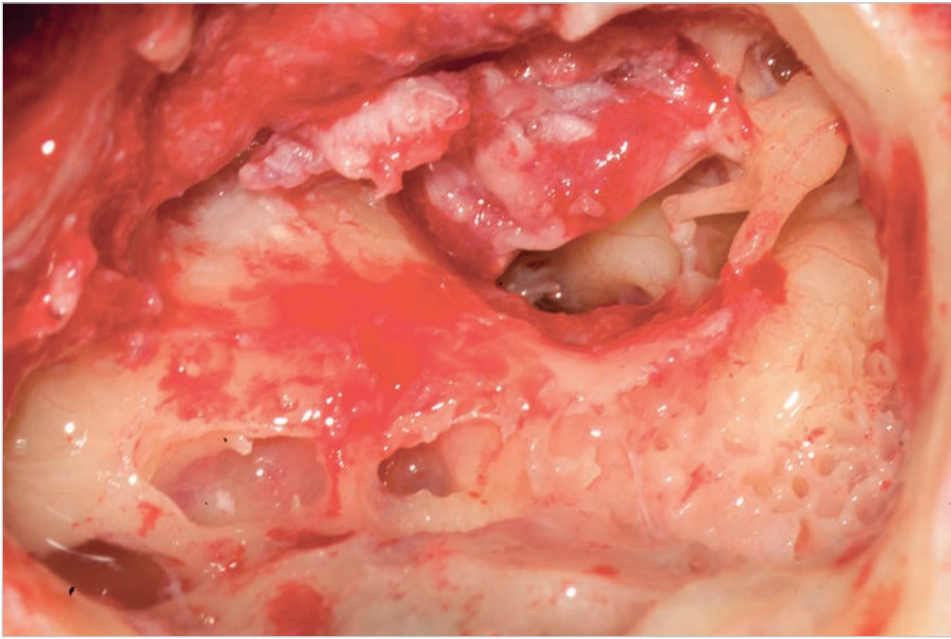


Fig. 9.19 The bone paste is covered with temporalis fascia, and the tympanomeatal flap is replaced. The meatus is packed with Gelfoam.

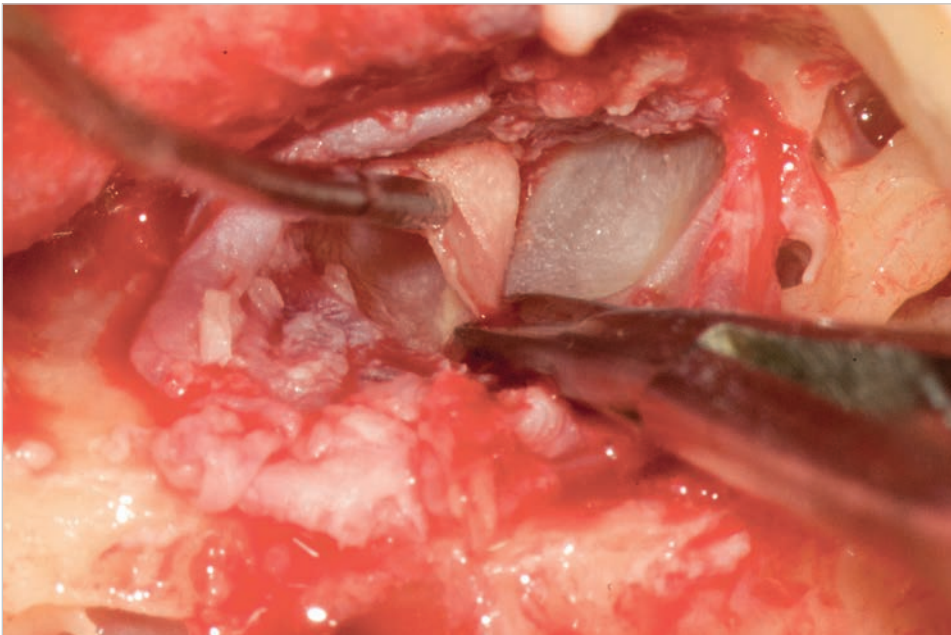


Fig. 9.20 The fold between the cholesteatoma in the inferior wall and the tympanic membrane is cut off to make their continuity smooth.

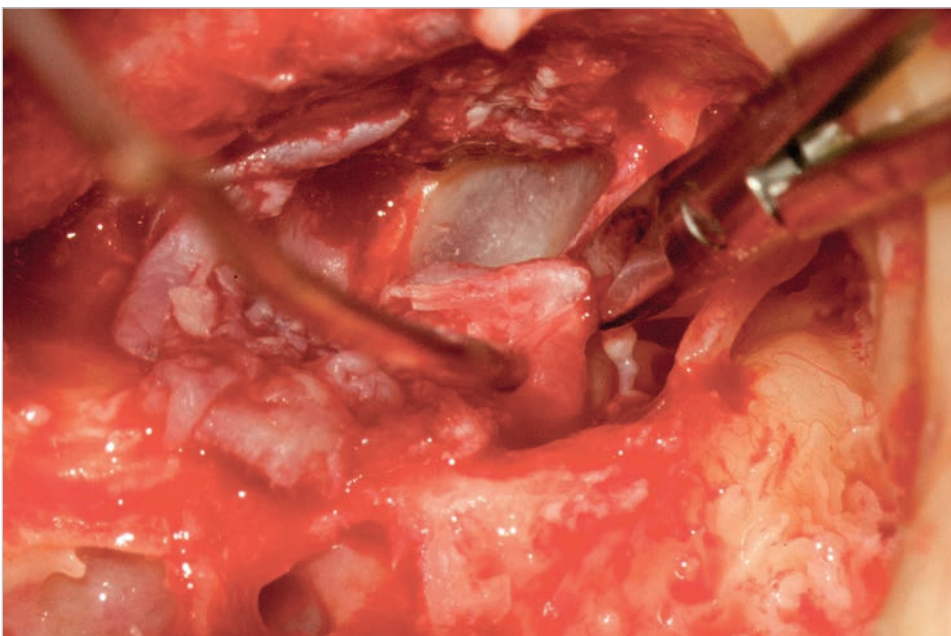


Fig. 9.21 The inflamed skin together with the matrix and granulation tissue of cholesteatoma was cut away to reach the area of healthy skin.

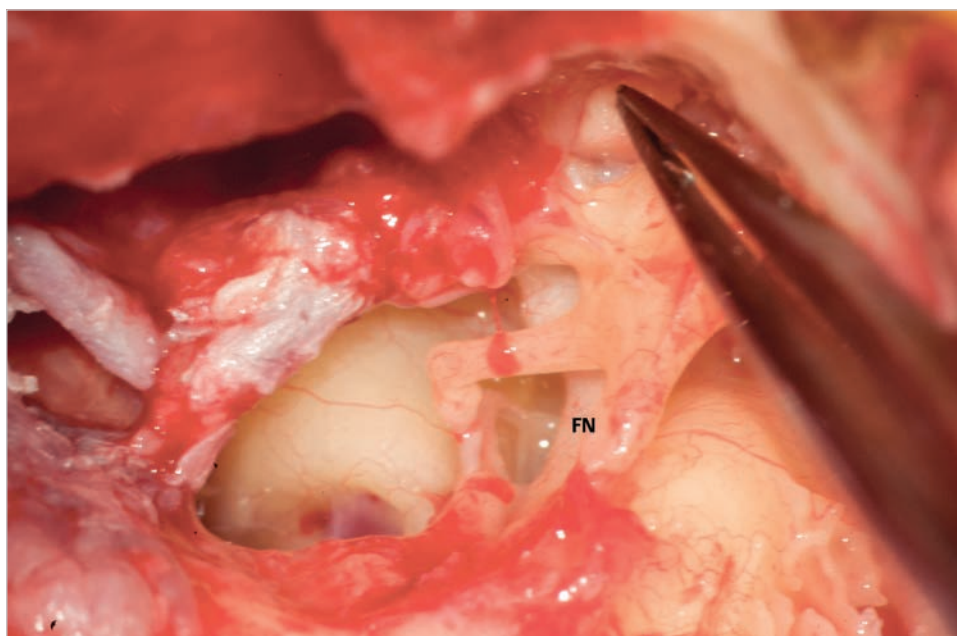


Fig. 9.22 The supratubal recess is obliterated with a small piece of cartilage. FN, facial nerve.

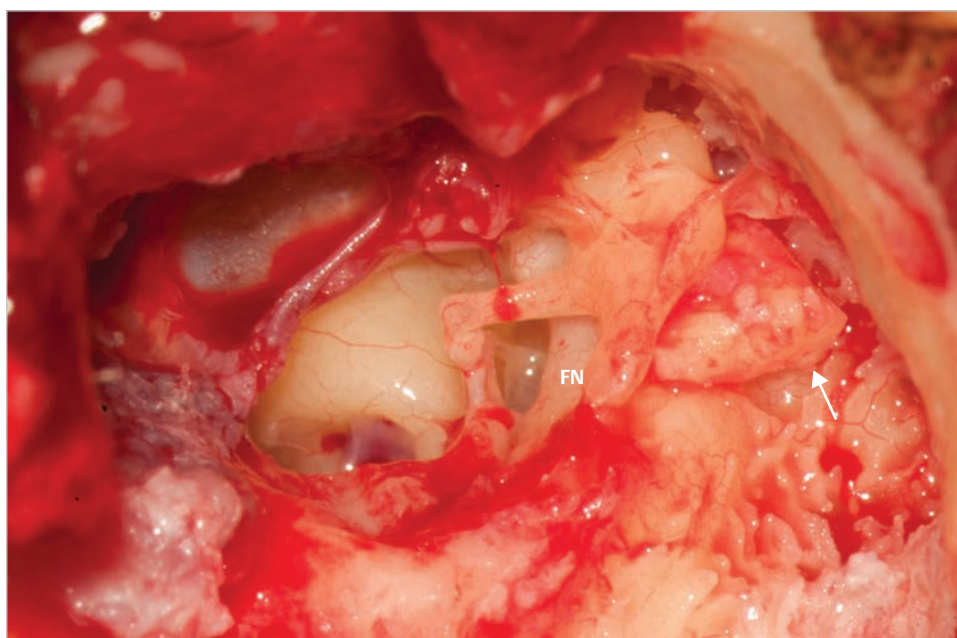


Fig. 9.23 A large piece of cartilage (arrow) is placed under the incus to prevent postoperative invagination of the skin toward the tympanic cavity. FN, facial nerve.

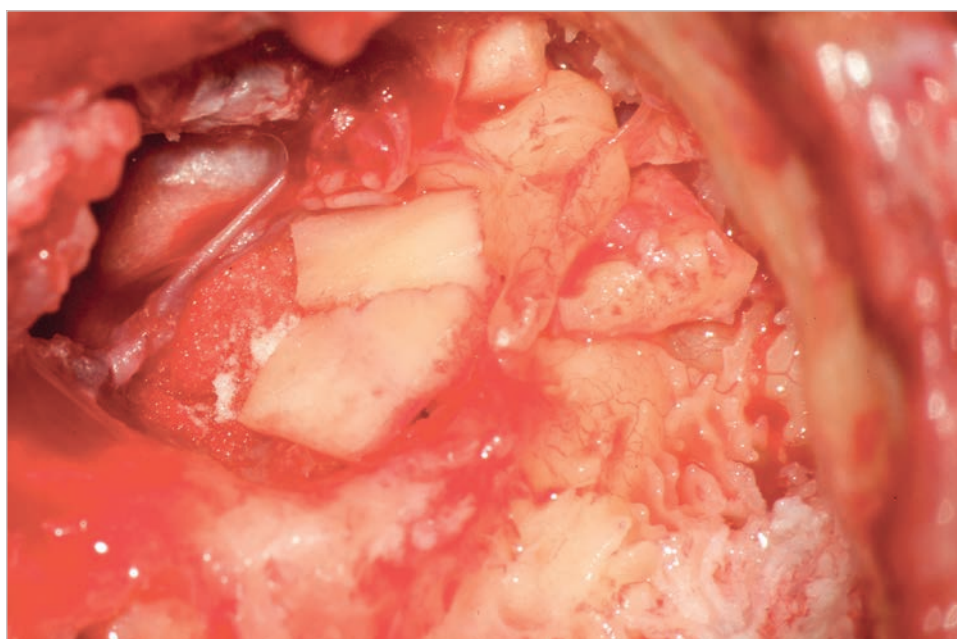


Fig. 9.24 The tympanic cavity is packed with Gelfoam. Two thin pieces of cartilage are placed over the Gelfoam to reinforce the posterosuperior quadrant of the tympanic membrane.

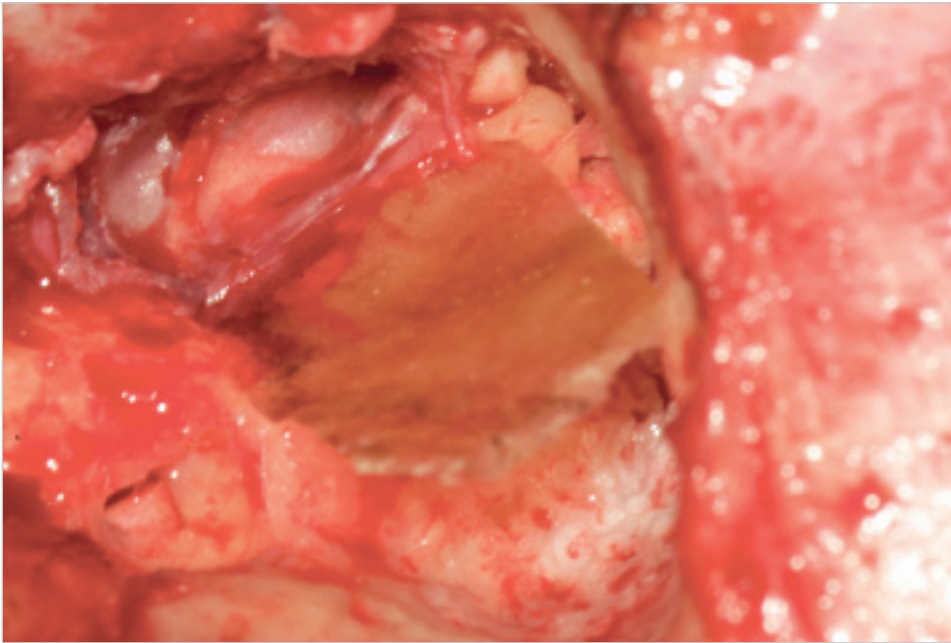


Fig. 9.25 A large piece of cartilage is introduced in the tympanic cavity to reconstruct the tympanic membrane and to cover the medial wall of the mastoid cavity. Pieces of cartilage are used to obliterate the large mastoid tip.

Case 9.3 (Left Ear)

See ► Fig. 9.26, ► Fig. 9.27, ► Fig. 9.28, ► Fig. 9.29, ► Fig. 9.30, ► Fig. 9.31, ► Fig. 9.32, ► Fig. 9.33, ► Fig. 9.34, ► Fig. 9.35, ► Fig. 9.36, ► Fig. 9.37.

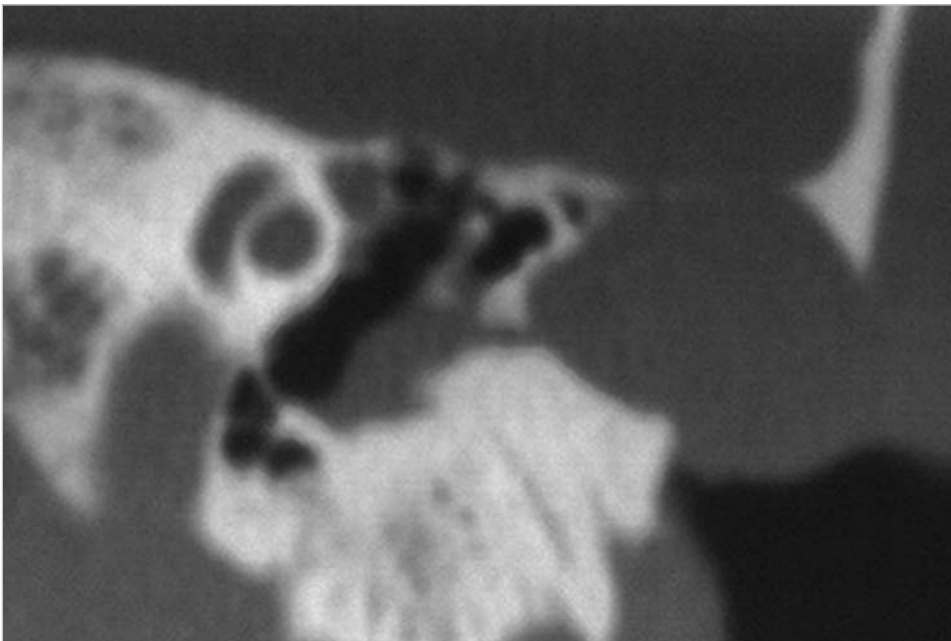


Fig. 9.26 A case of iatrogenic cholesteatoma in the external auditory canal. The patient underwent surgery for exostosis, and hearing loss followed the surgery. The preoperative coronal CT demonstrates formation of large cholesteatoma eroding the middle fossa plate, and presence of exostosis just lateral to the tympanic membrane.

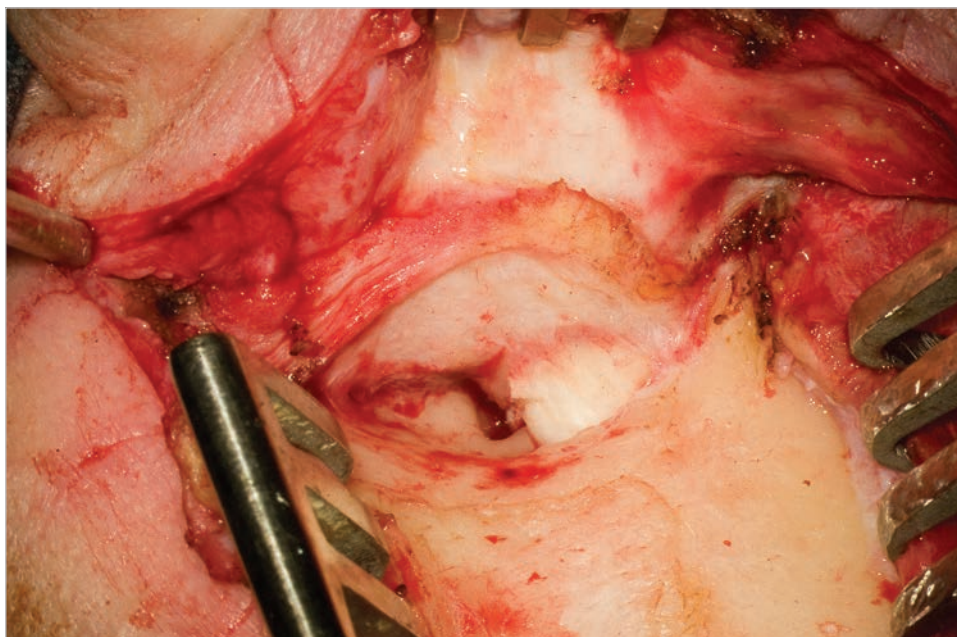


Fig. 9.27 The external auditory canal is entered through retroauricular incision. Elevation of the posterior meatal skin revealed a large bony erosion in the posterosuperior wall, and accumulated debris comes out from the mastoid.

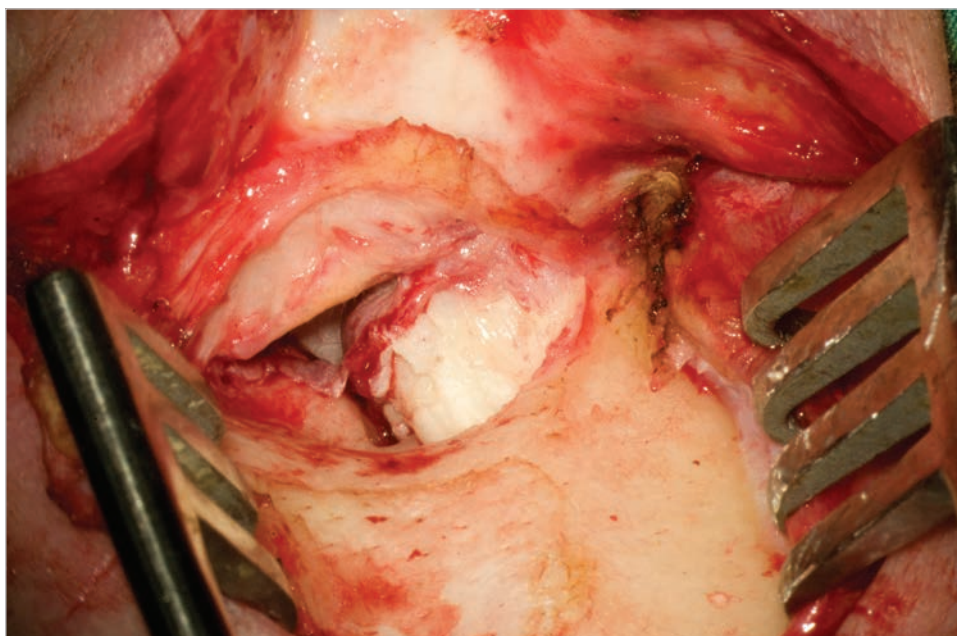


Fig. 9.28 The external auditory canal is entered by incising the meatal skin just laterally to the cholesteatoma.

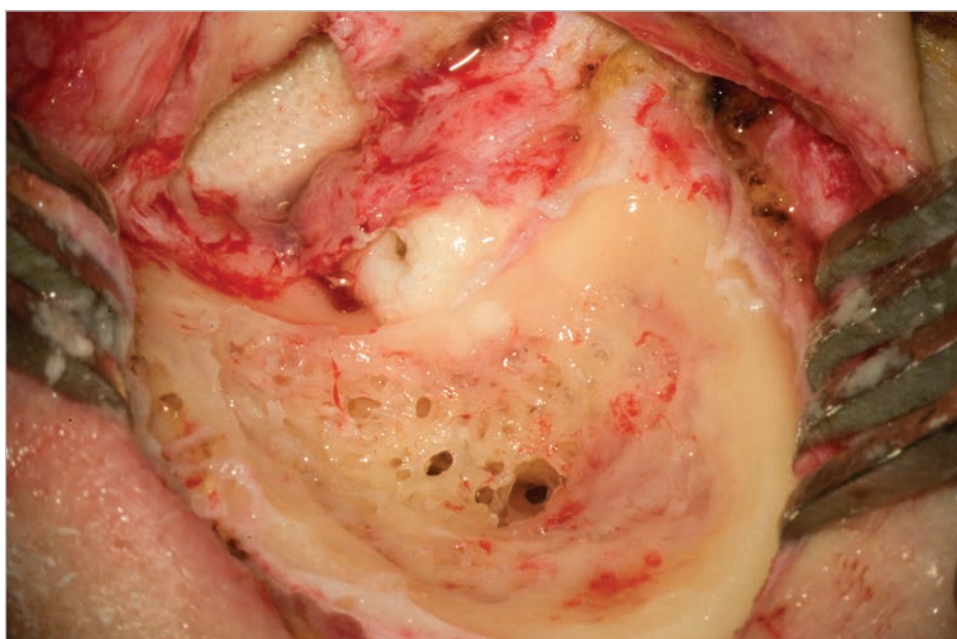


Fig. 9.29 A mastoidectomy revealed limited extension of the cholesteatoma in the mastoid.

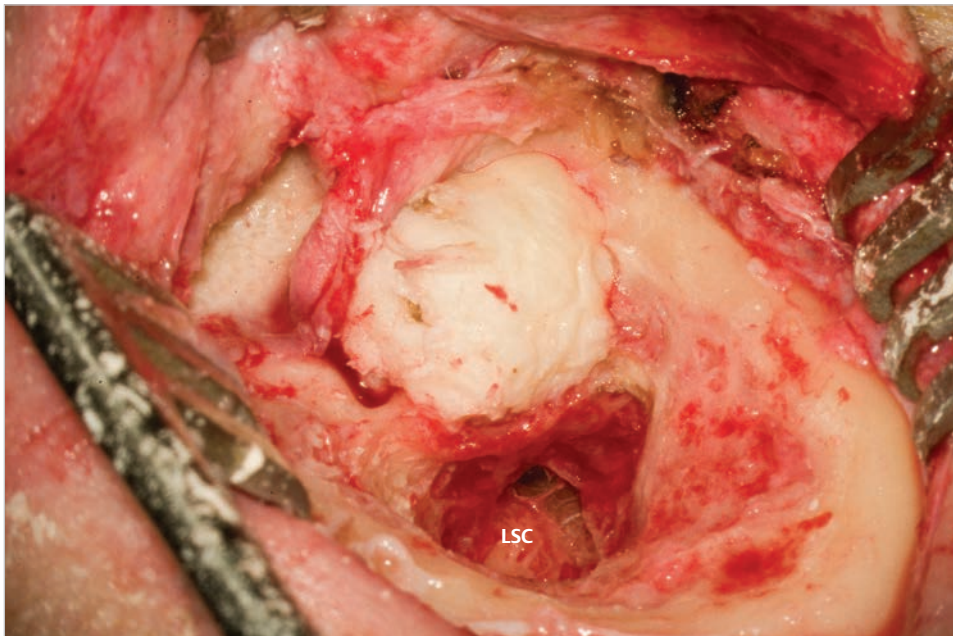


Fig. 9.30 Mastoidectomy is advanced medially to expose posterior face of the cholesteatoma. No pathology is found in the antrum. LSC, lateral semicircular canal.

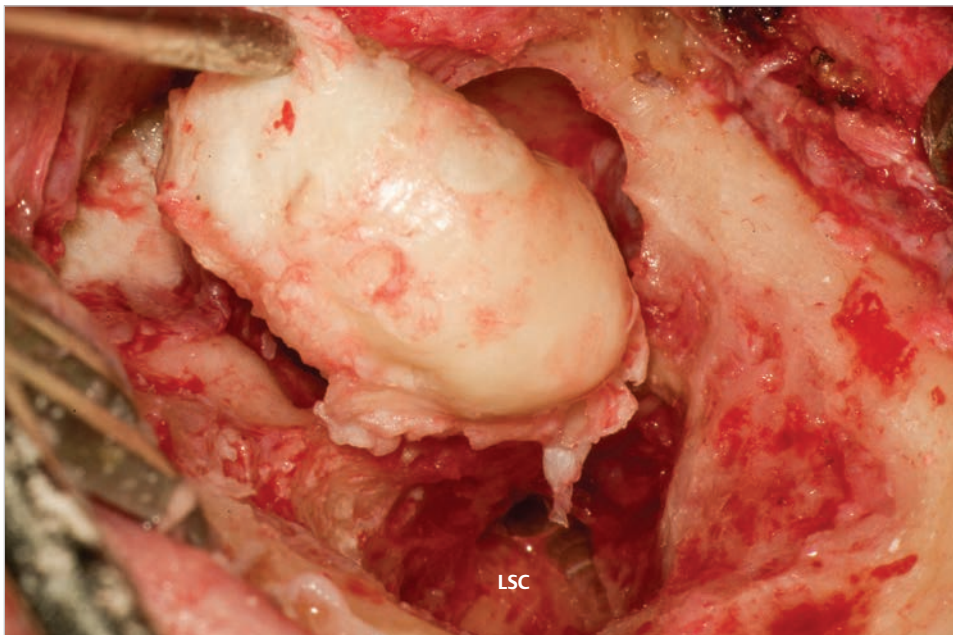


Fig. 9.31 Debris of the cholesteatoma is evacuated. LSC, lateral semicircular canal.

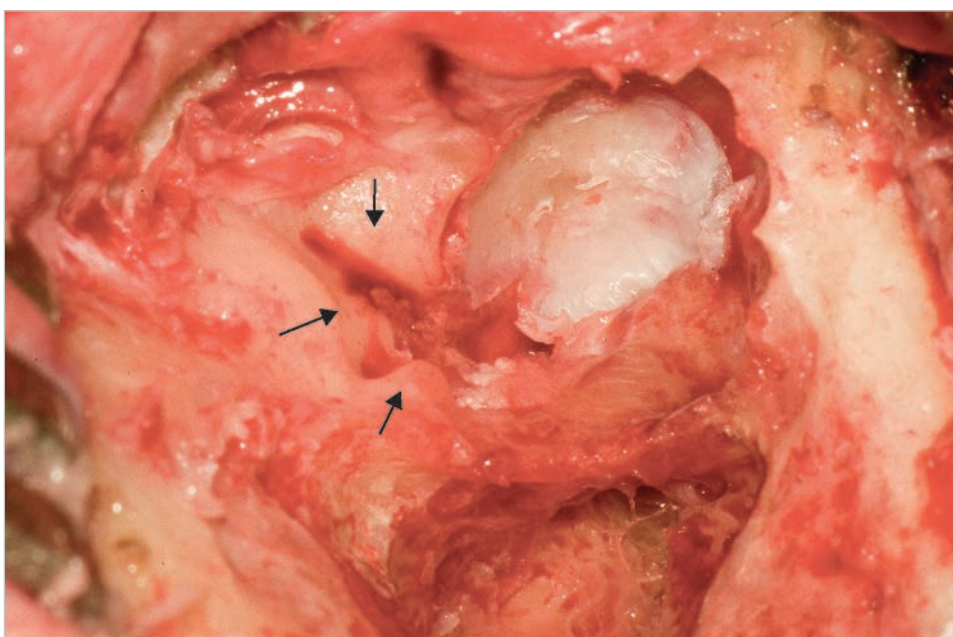


Fig. 9.32 Formation of exostosis closing the external auditory canal is seen (*arrows*). Skin covering the inner face of cholesteatoma is seen.

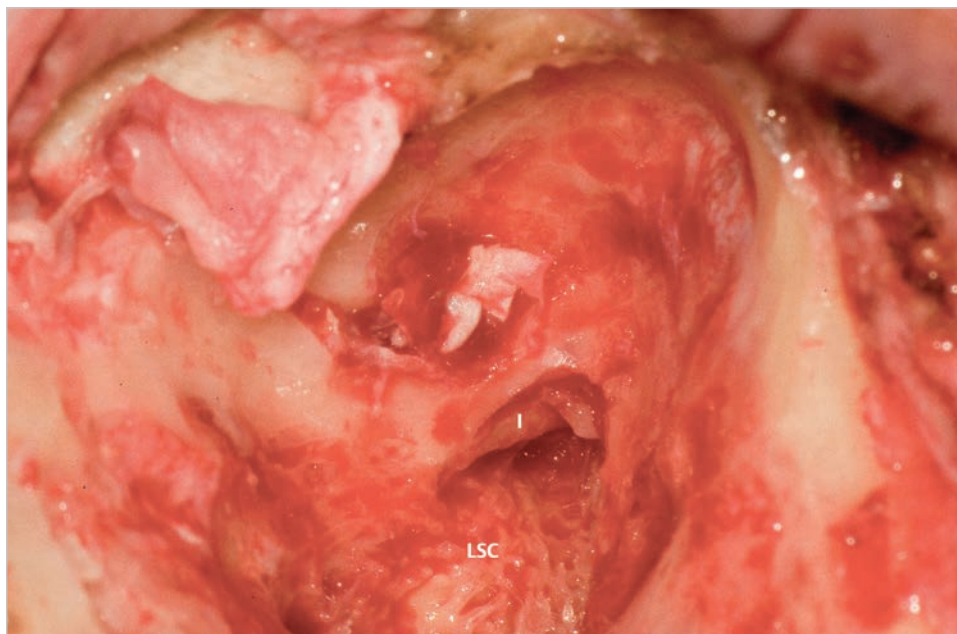


Fig. 9.33 Canal wall down mastoidectomy is advanced medially. The aditus ad antrum is enlarged to be seen the incus in the attic. I, incus; LSC, lateral semicircular canal.

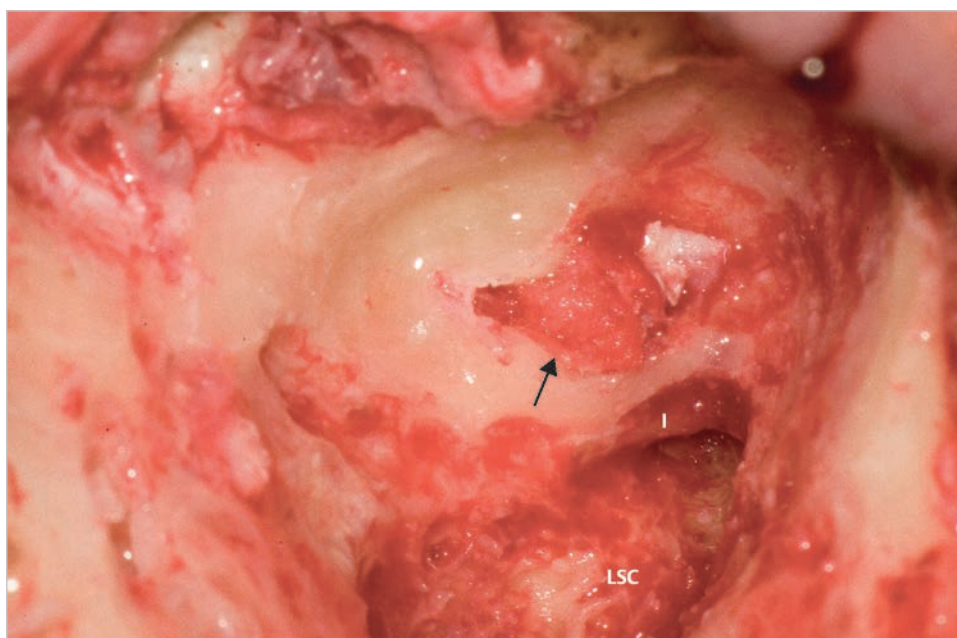


Fig. 9.34 The meatal skin is detached and reflected medially, and posterior wall is removed with exostosis. During this procedure, the meatal skin should be protected with cottonoid (*arrow*) and aluminum sheeting to preserve is as much as possible. I, incus; LSC, lateral semicircular canal.



Fig. 9.35 The most medial part of exostosis is shown. I, incus.

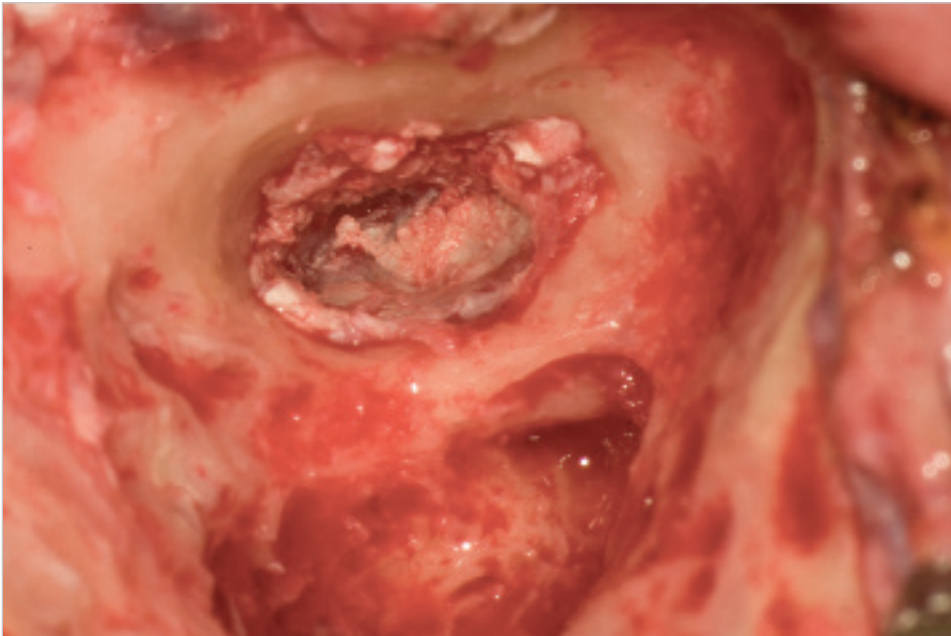


Fig. 9.36 The exostosis is completely removed. No pathologic change is seen in the tympanic membrane at the bottom of the canal. Since the ossicular chain remains intact even though the extensive erosion of the posterior wall, the mastoid cavity is obliterated with cartilage, and covered with a large piece of temporalis fascia.

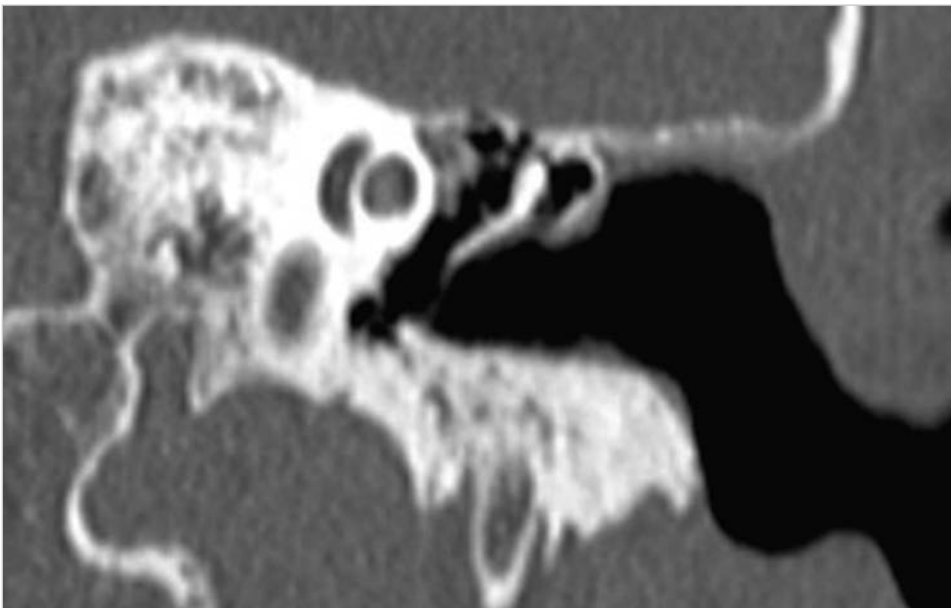


Fig. 9.37 The postoperative coronal CT shows complete removal of the exostosis resulting in enlarged clear external auditory canal.

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10 Problems and Solutions in Middle Ear Cholesteatoma Surgery

10.1 Labyrinthine Fistula

In our experience, labyrinthine fistulas complicate about 10% of cholesteatomas we operated on (►Fig. 10.1). In all cases of cholesteatoma, the presence of a labyrinthine fistula should be assumed during surgery until its absence is verified. Lack of any inner ear symptom or signs of a fistula does not mean that the labyrinth is intact. The lateral semicircular canal, located superficially in the vicinity of the attic, is the site most commonly involved (►Fig. 10.2).

The choice between canal wall down or up technique, depends mainly on how far the disease has extended and the size of the mastoid (see *Indications* in Chapters 6 and 7). When canal wall down technique is used, it is better to leave the matrix on the fistula to avoid postoperative labyrinthitis. Therefore, according to our strategy in which the closed technique is used only in limited numbers of cases, the posterior wall is usually removed and the matrix is left in place. If the extent of the disease and the status of the mastoid allow the closed technique to be used, treatment of a labyrinthine fistula depends on its size. In many cases, the fistula is already large (> 2 mm) at the time of operation. In such cases and those with fistulas in the ear with better hearing, canal wall down techniques are indicated and the cholesteatoma matrix is left over the fistula, to avoid deaf ear (►Fig. 10.3, ►Fig. 10.4, ►Fig. 10.5). In canal wall down tympanoplasty, since the fistula is exteriorized in the cavity with the matrix left in place, second-stage surgery for the fistula is not necessary.

Cholesteatoma with fistulas smaller than 2 mm may be treated with canal wall up techniques. When canal wall up technique is used, management of the fistula depends on its size. If the matrix is cut with a sufficient margin, the matrix covering the fistula is isolated from the surrounding area, and most of the cholesteatoma is dissected from the middle ear. To avoid keeping the inner ear open for a long time, further management on the fistula should be performed at the end of surgery when all the reconstructions are completed and materials to cover the fistula are available. If the fistula is less than 1 mm in size, the matrix covering the fistula can be removed. Blunt dissection of the matrix is done carefully with a microdissector and a small cottonoid under continuous suction irrigation (►Fig. 10.6). The opening in the labyrinth (►Fig. 10.7) should immediately be closed with bone paste, and the area covered with a piece of either temporal fascia or perichondrium (►Fig. 10.8, ►Fig. 10.9). If the matrix is adherent to the membranous labyrinth or the fistula is larger than 1 mm, the matrix is left in place, even in canal wall up technique. To reduce the epidermis and to interrupt its possible

nutrient pathways, the matrix is trimmed with a sharp knife, leaving a small matrix that is less than 1 mm larger than the margin of the fistula. Meticulous care should be taken not to enter the labyrinth. If the labyrinth is entered, the matrix is removed and the fistula is managed as described above. If the canal wall up technique is implemented, second-stage surgery should be planned within 6 months. In our experience, the epidermis left over the fistula in closed technique disappears in 70% of cases, or in the remainder forms an easy-to-remove pearl at the second stage (►Fig. 10.10).

In some cases, the fistulas get local inflammation that lead to closure of the semicircular canal with fibrosis. Removal of the matrix is possible in such cases even when the fistula is large. The condition can be diagnosed preoperatively with heavily T2-weighted magnetic resonance imaging (MRI). Another case of safe removal of the skin from large labyrinthine fistula is a thick coverage over it. In such condition, the surgeon can remove only the superficial part of its coverage using sharp scissors, and removal of skin without entering the labyrinth is achieved. In such cases, the area of the fistula can be covered with bone paste to reduce possibility of labyrinthitis.

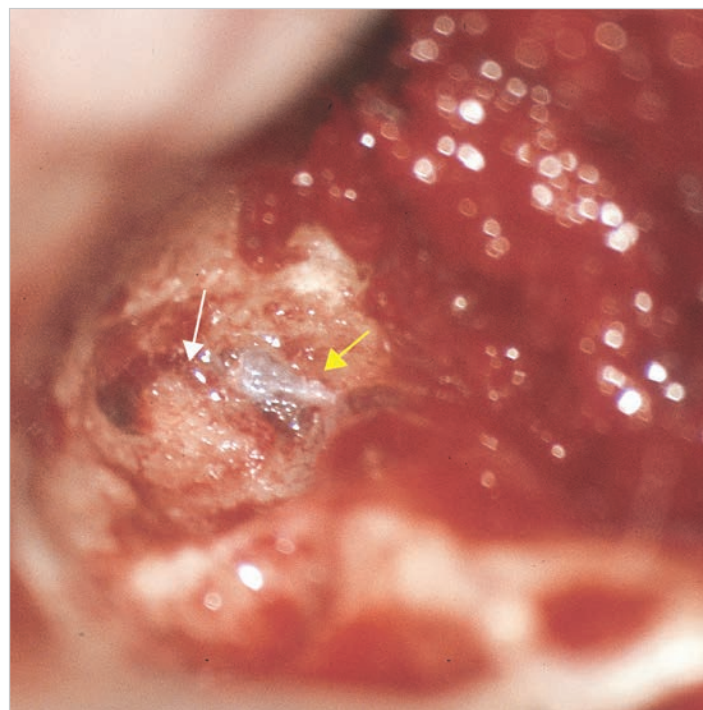


Fig. 10.1 A case of cholesteatoma with labyrinthine fistulae in the right ear. In both superior (white arrow) and lateral (yellow arrow) semicircular canals, labyrinthine fistulas are clearly seen after removal of the cholesteatoma matrix.

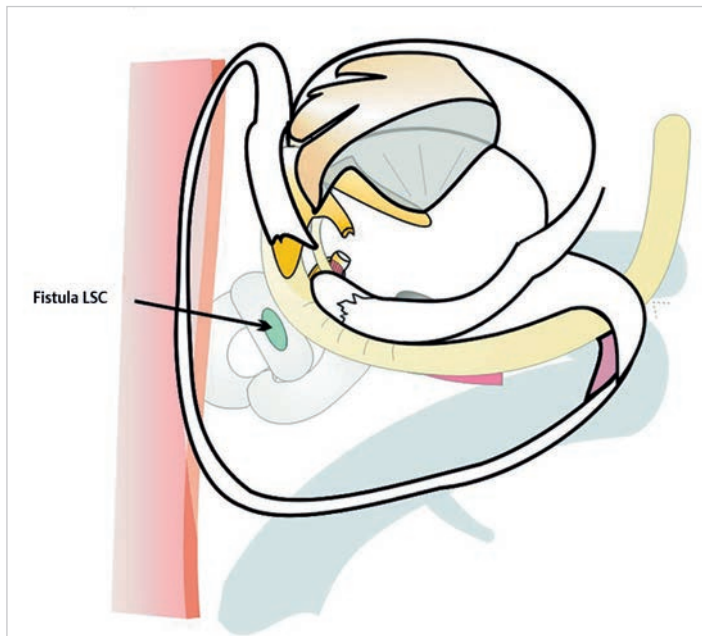


Fig. 10.2 The commonest site for labyrinthine fistula. LSC, lateral semicircular canal.

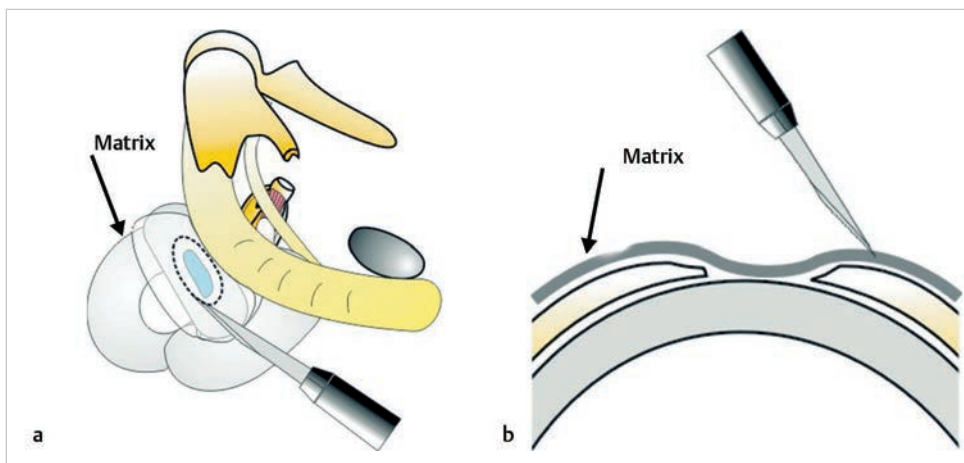


Fig. 10.3 (a, b) Cholesteatoma matrix is dissected using a sharp knife.

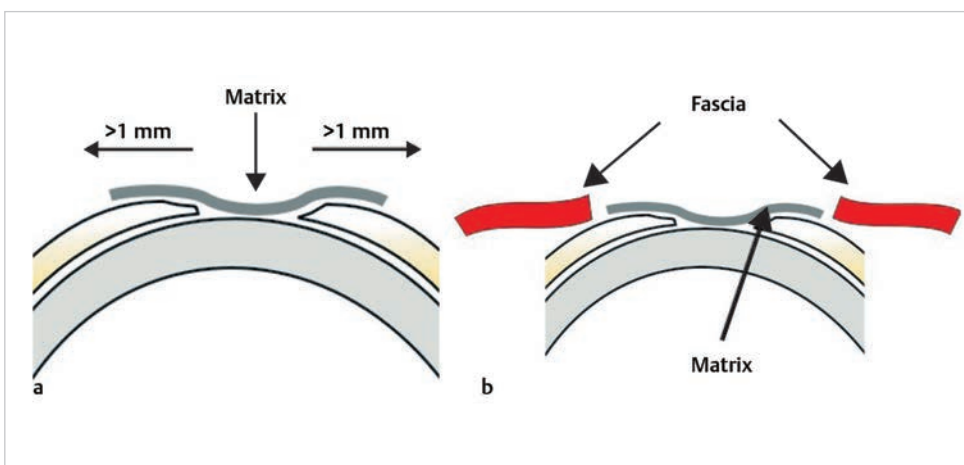


Fig. 10.4 (a) Matrix is left in place. (b) Matrix is exteriorized through the fascia.

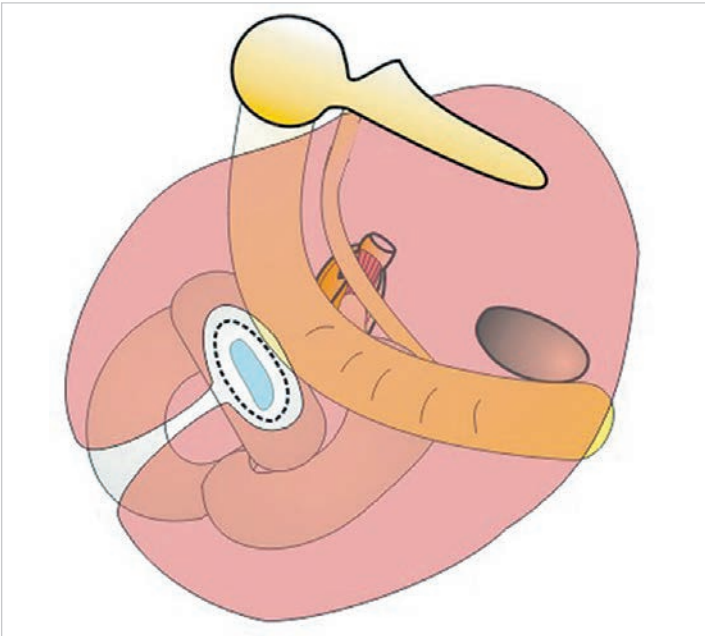


Fig. 10.5 View at the end.

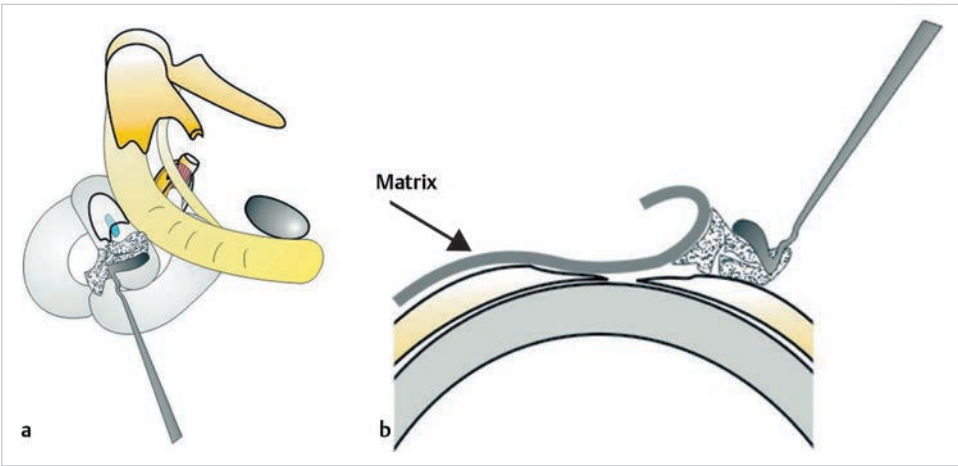


Fig. 10.6 (a, b) Dissecting the cholesteatoma matrix from a small fistula.

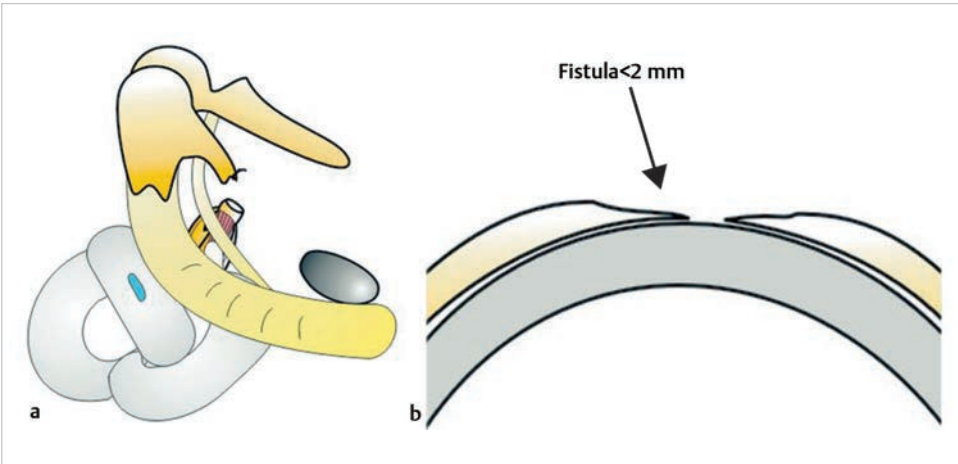


Fig. 10.7 (a, b) View of the fistula after matrix removal.

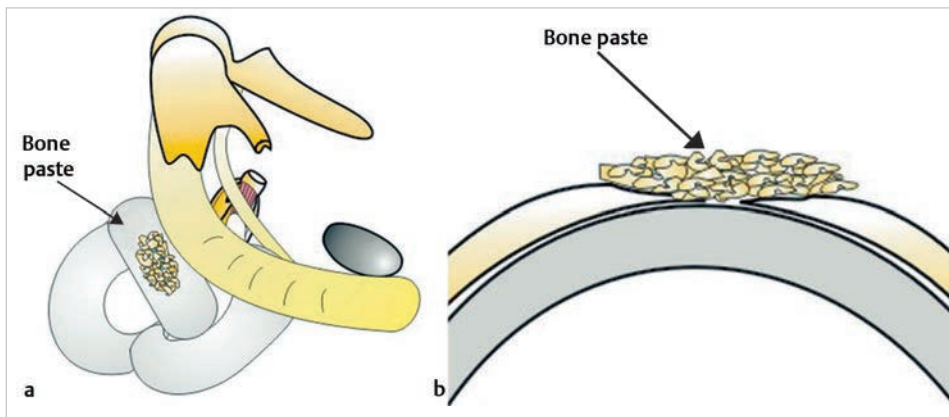


Fig. 10.8 (a, b) The fistula is immediately covered with bone paste.

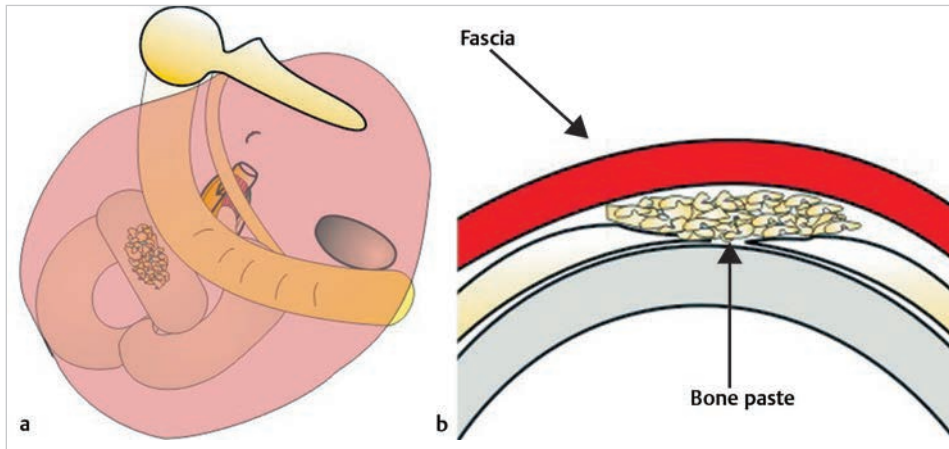


Fig. 10.9 (a, b) Fascia overlying the matrix and bone paste.

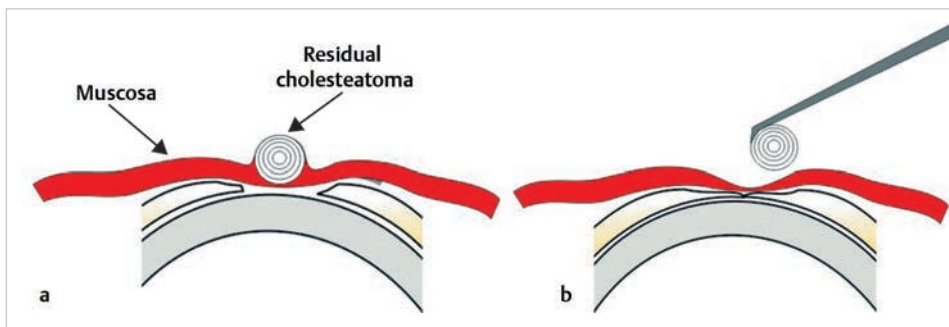


Fig. 10.10 (a, b) Removal of residual cholesteatoma during second-stage surgery.

10.2 Bone Erosion in the Tegmen

Bone erosion in the tegmen is seen frequently in cholesteatoma surgery. It may eventually cause meningoencephalic herniation (see Chapter 10.5). Patients with meningoencephalic herniation have a high risk of liquorrhea, meningitis, and epilepsy caused by an epileptogenic focus in the herniating brain tissue. Since the presence of both the erosion in the tegmen and labyrinthine fistulas usually mean progression of destructive process in the attic and the antrum, they often complicated with each other. In such cases, management of both complications simultaneously is required.

To prevent these complications, large erosions should be repaired with cartilage and bone paste, and the area covered with fascia. If a small area of the middle cranial fossa dura is exposed but not protrude into the canal wall up cavity, it can be left in place. If it is seen in the canal wall down cavity, a pedicled subcutaneous tissue flap may be harvested (from beneath the concha cartilage during the later meatoplasty) and placed over that area.

Case 10.1 (Right Ear)

See ► Fig. 10.11, ► Fig. 10.12, ► Fig. 10.13, ► Fig. 10.14.

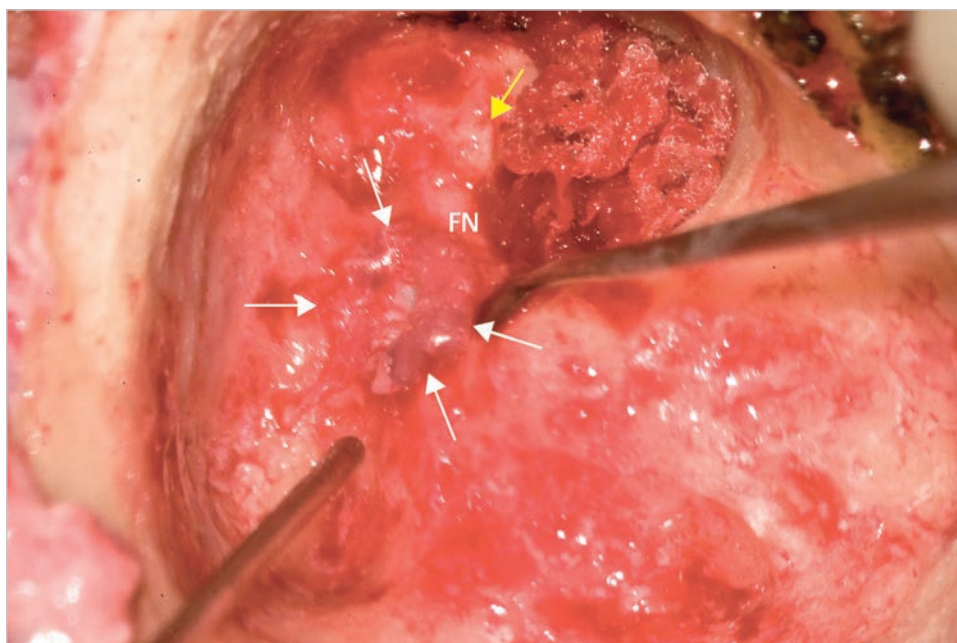


Fig. 10.11 Management of labyrinthine fistula in the lateral semicircular canal. The majority of cholesteatoma has already been removed from the middle ear except the thickened and inflamed skin (*white arrows*) covering the area of fistula. The tympanic segment of the facial nerve courses just superiorly to the cochleariform process (*yellow arrow*).

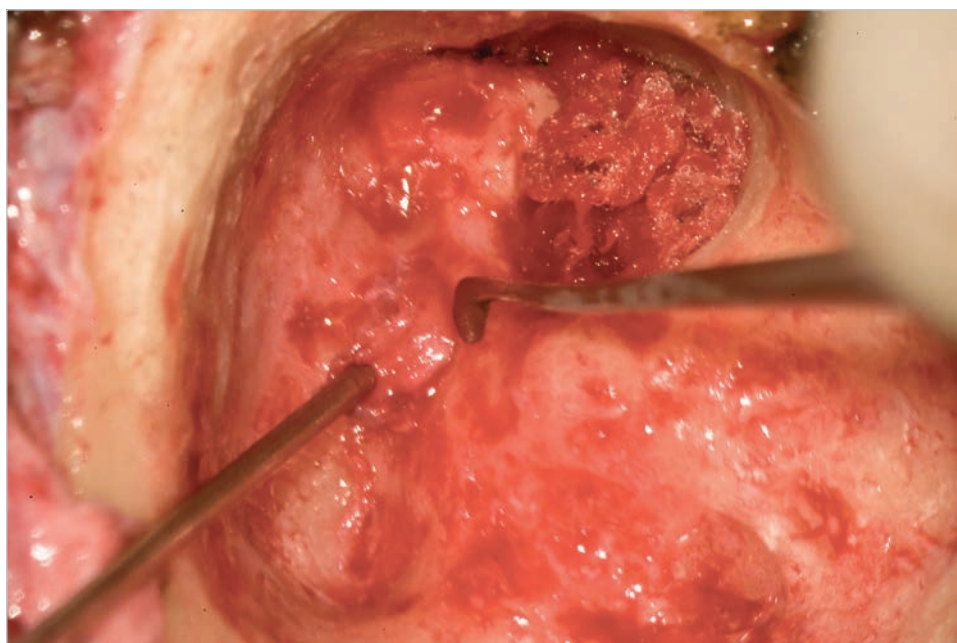


Fig. 10.12 The skin covering the fistula is started to be dissected toward the fistula taking care not to open the inner ear.

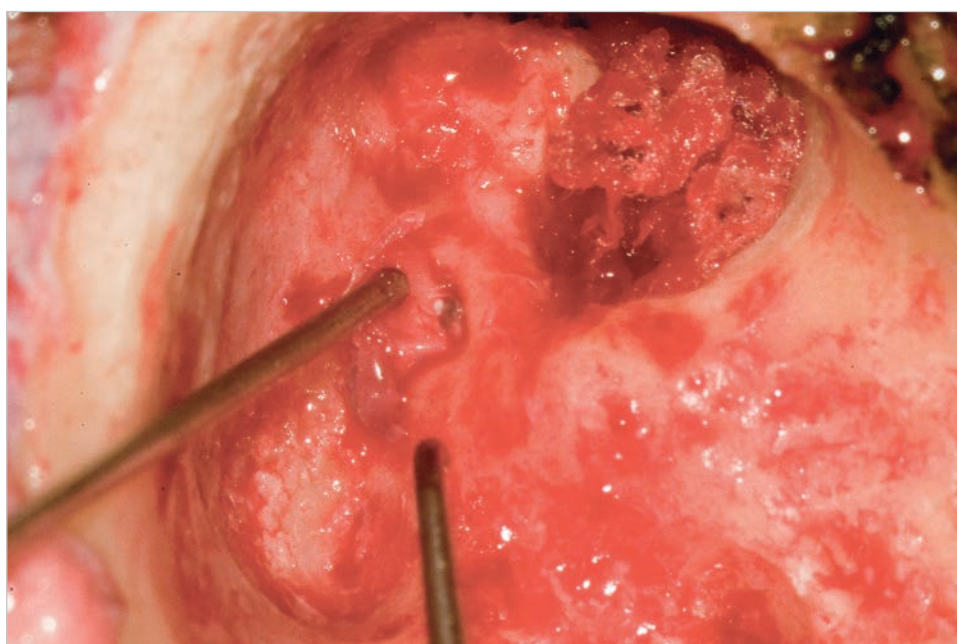


Fig. 10.13 A small piece of skin covering the fistula is cut out, and rest of inflamed skin is removed.

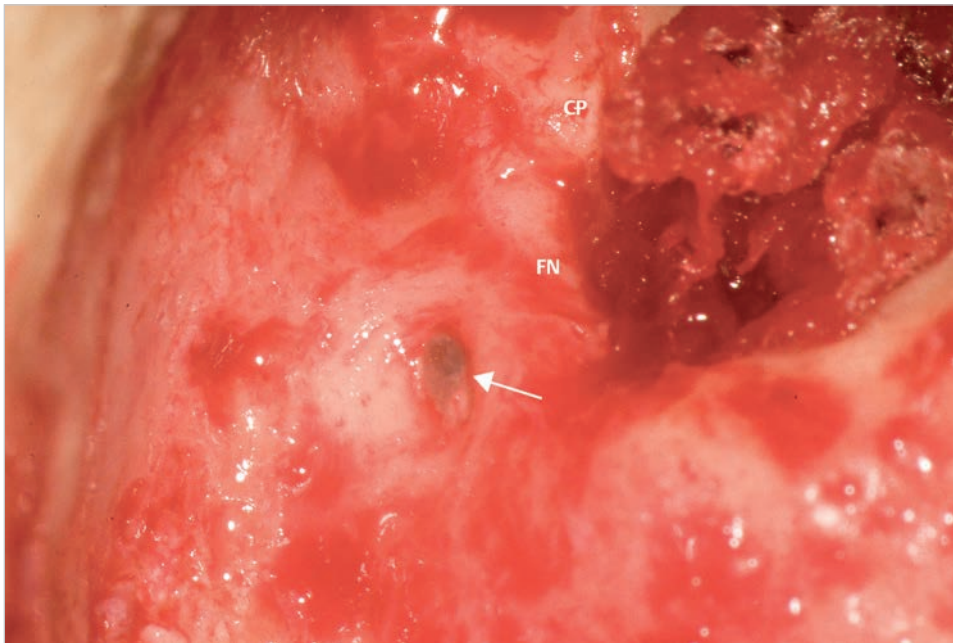


Fig. 10.14 The final status of the labyrinthine fistula is shown (arrow). The fistula covered with a small piece of skin is located in a bony bulge just superiorly to the facial nerve. In reconstruction, the medial wall of the cavity is covered with pieces of fascia, leaving the area of the fistula. CP, cochleariform process; FN, facial nerve.

Case 10.2 (Right Ear)

See ► Fig. 10.15, ► Fig. 10.16, ► Fig. 10.17, ► Fig. 10.18, ► Fig. 10.19, ► Fig. 10.20, ► Fig. 10.21, ► Fig. 10.22, ► Fig. 10.23, ► Fig. 10.24, ► Fig. 10.25, ► Fig. 10.26, ► Fig. 10.27.

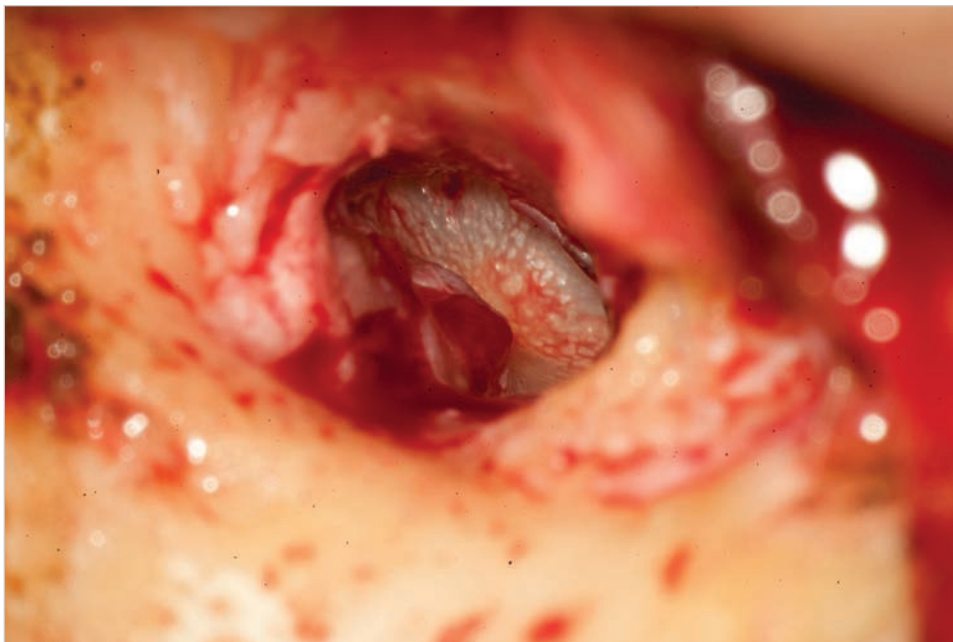


Fig. 10.15 Viaretroauricular incision, the external auditory canal is entered. Granulation tissue is seen in the pars flaccida. Note the limited access to the tympanic membrane at this moment.

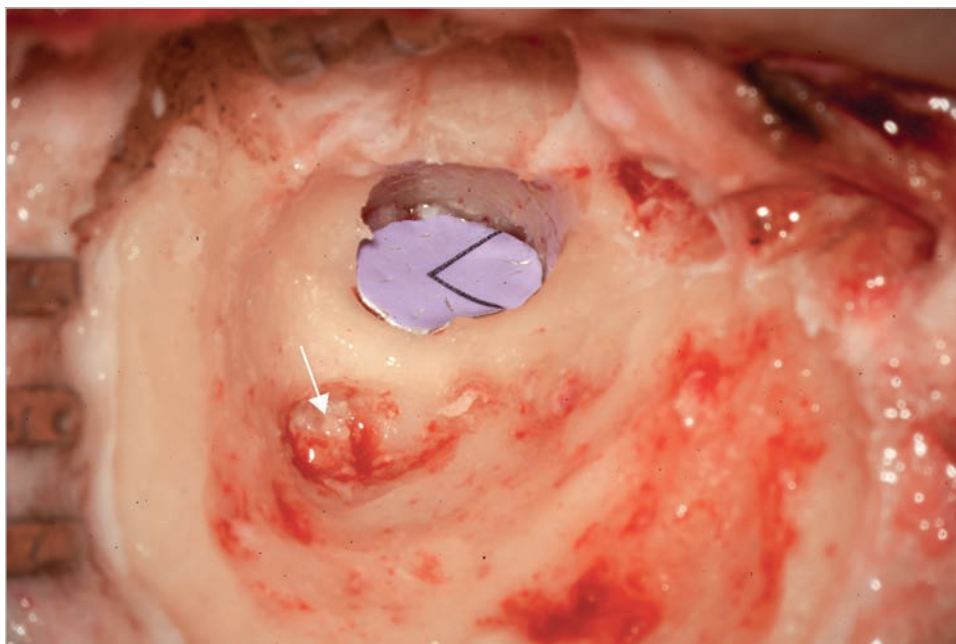


Fig. 10.16 The posterior wall is removed to reach the area of the tympanic membrane and to open the small antrum. Cholesteatoma in the antrum is started to be seen (*arrow*). The tympanic membrane is protected with an aluminum sheeting.

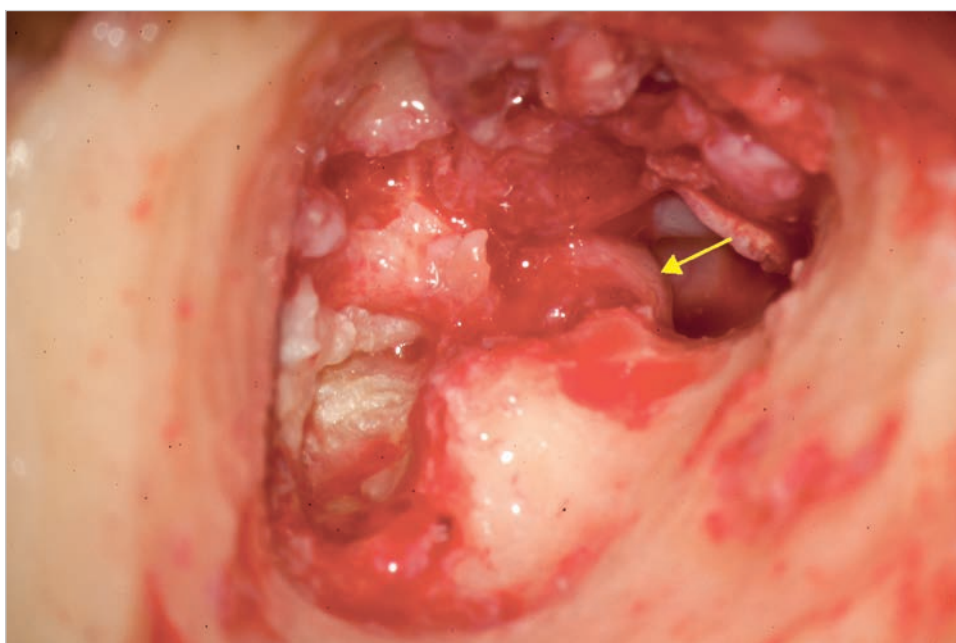


Fig. 10.17 Cholesteatoma filling the attic and the small mastoid is visualized. The tympanic membrane is detached from the bony annulus, and the tympanic cavity is opened. Cholesteatoma descending to the posterior mesotympanum is visualized (*arrow*).

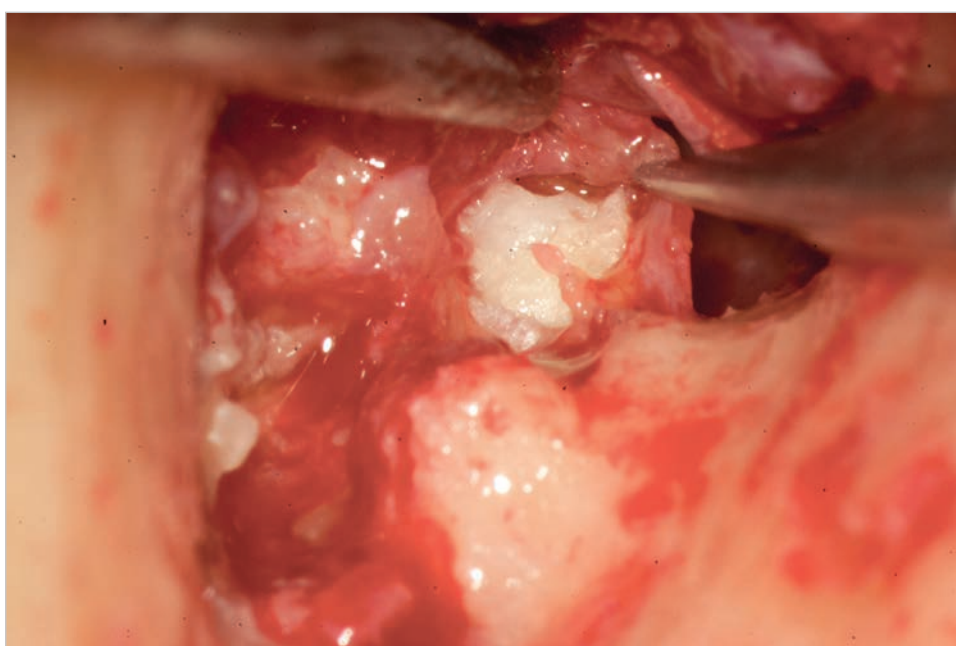


Fig. 10.18 Thick mucosal sac covering cholesteatoma descending to the posterior mesotympanum is opened.

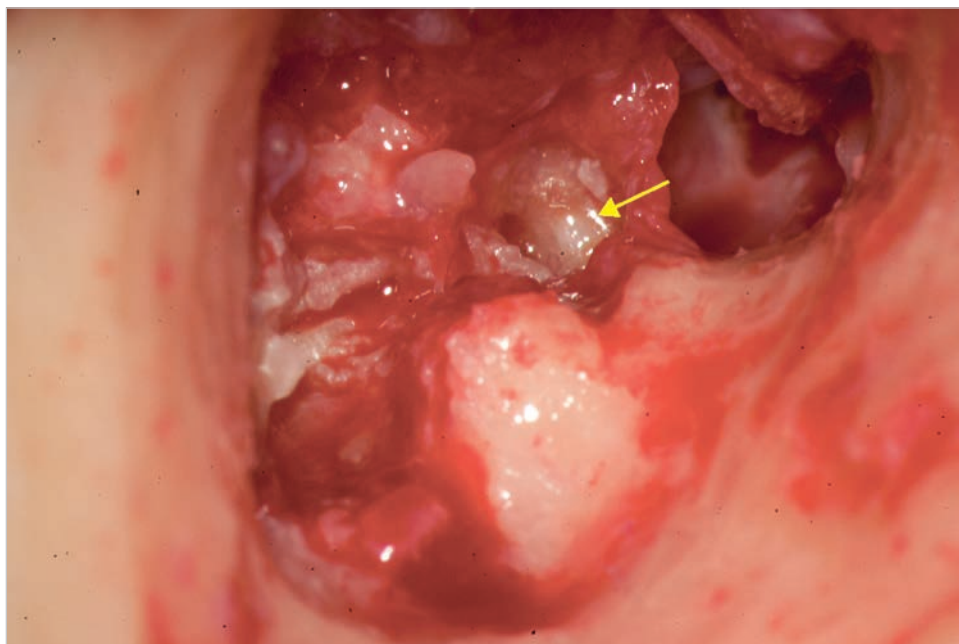


Fig. 10.19 Evacuation debris visualized the head of the stapes (*arrow*) under the matrix.

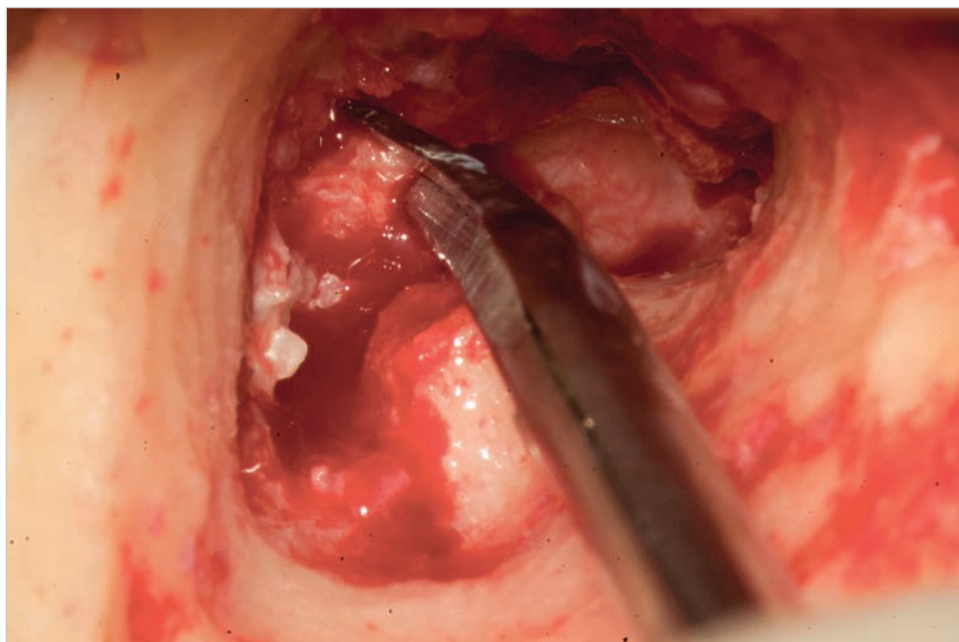


Fig. 10.20 The head of the malleus is cut with scissors to make access to the cholesteatoma invaginating anteriorly and medially to it.

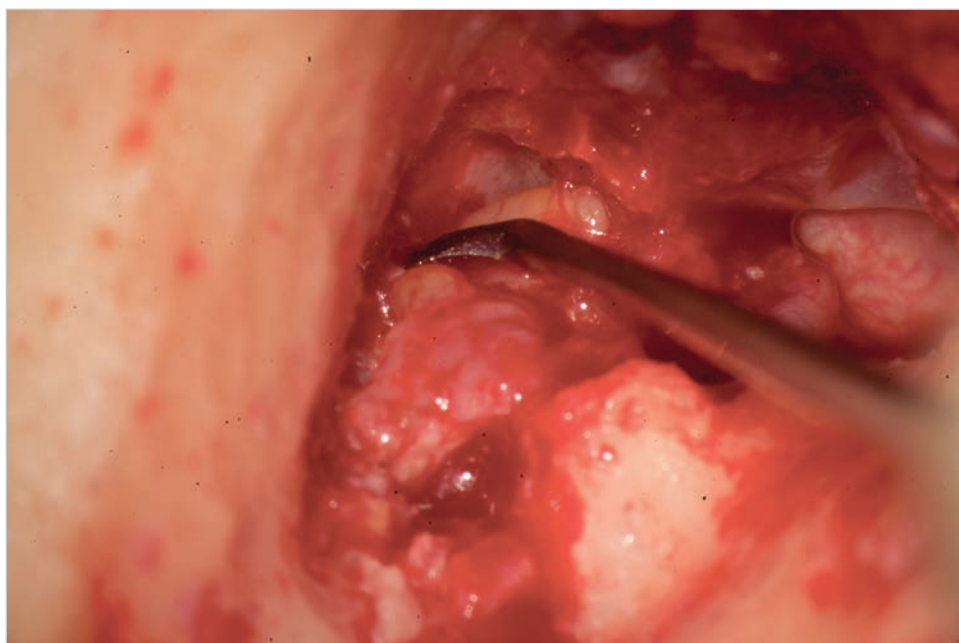


Fig. 10.21 Cholesteatoma filling the supratubal recess is dissected.

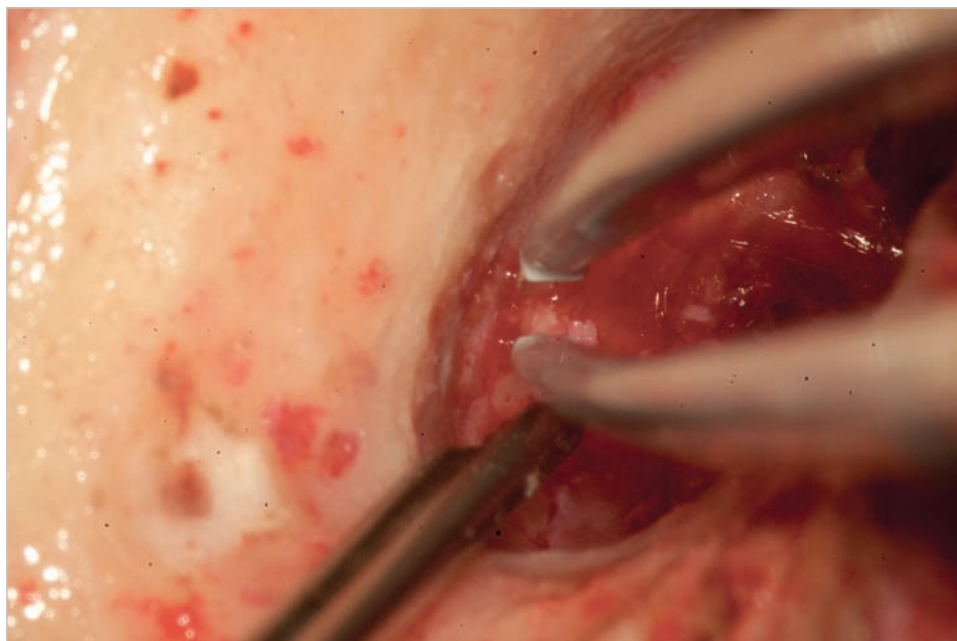


Fig. 10.22 The small area of middle fossa dura uncovered in the tegmen of the antrum is coagulated with bipolar to eliminate risk of leaving matrix over it.

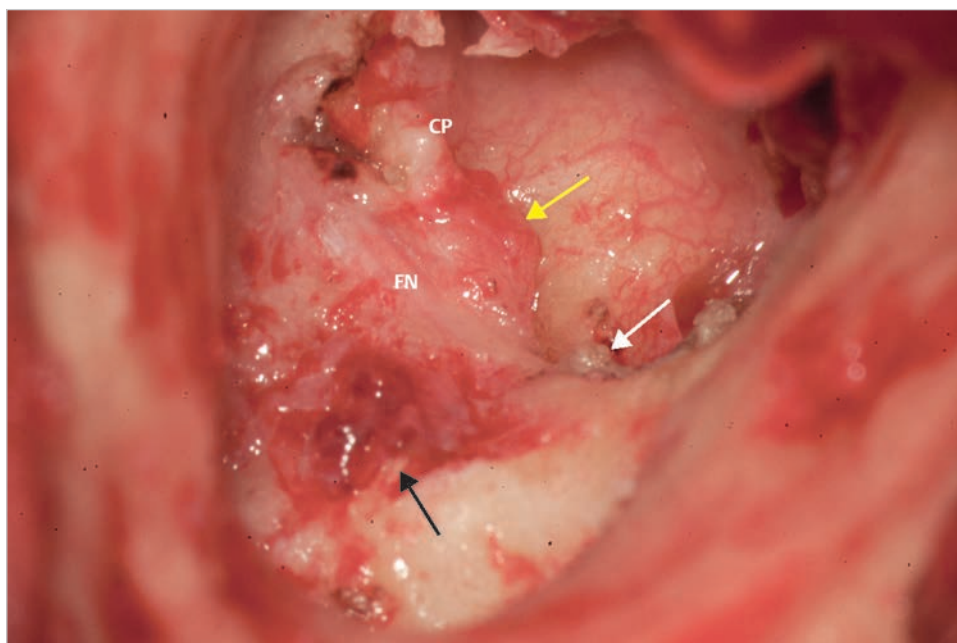


Fig. 10.23 The majority of cholesteatoma is removed from the middle ear. Once the inner ear is opened, it should be closed as soon as possible to avoid labyrinthitis. For that sake, further management of fistula is reserved for the last moment, and a small piece of inflamed skin is left over the fistula (*black arrow*). The facial nerve is exposed and prominently bulged (*yellow arrow*) just behind the cochleariform process. The stapes (*white arrow*) can be identified posteriorly to the bulge. CP, cochleariform process; FN, facial nerve.

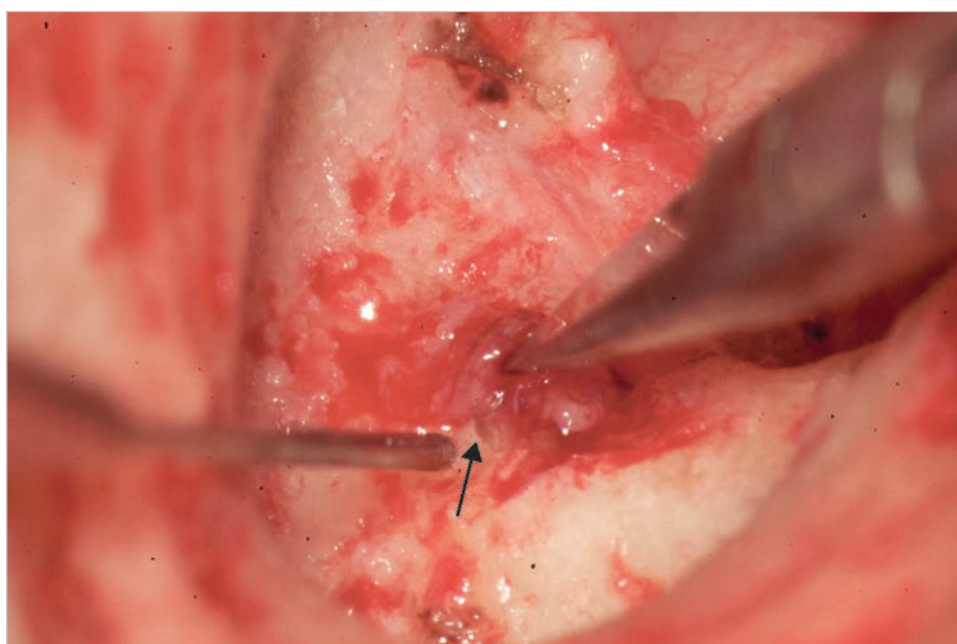


Fig. 10.24 In this particular case, the surface of the thick coverage over the fistula is cut out taking care not to open the lateral semicircular canal (*arrow*).

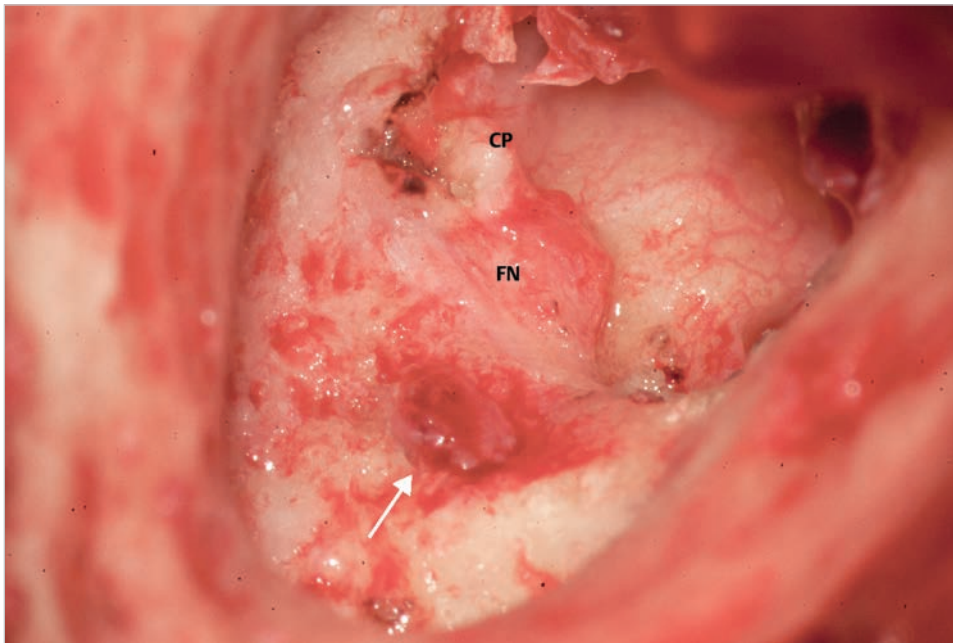


Fig. 10.25 Removal of the skin covering the fistula is accomplished (*arrow*). Note the huge bulge of the facial nerve just behind the cochleariform process. CP, cochleariform process; FN, facial nerve.

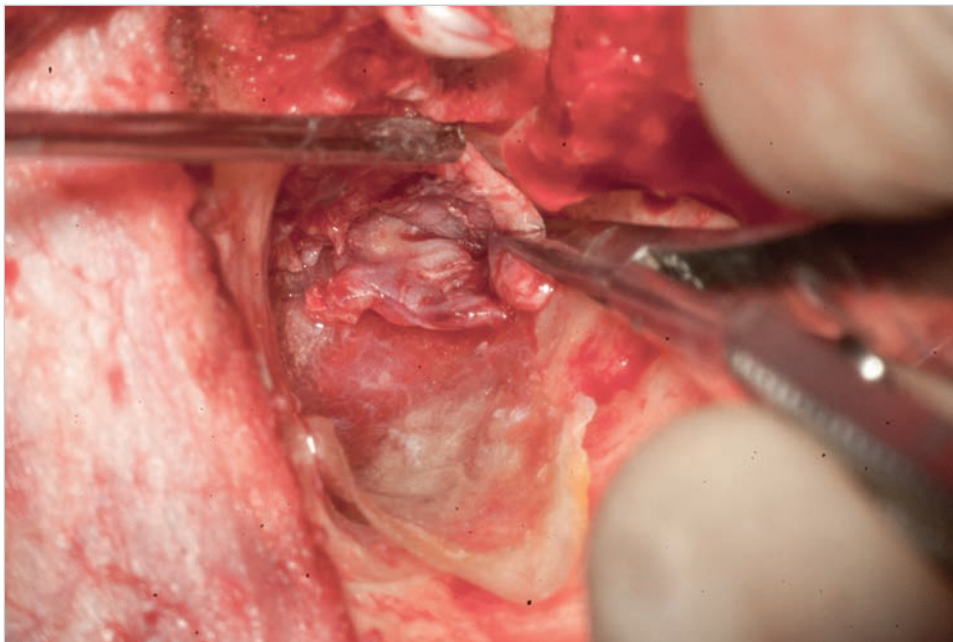


Fig. 10.26 The temporalis fascia is grafted underlay. A plastic cut is made in the inferior meatal skin for intimate lining.

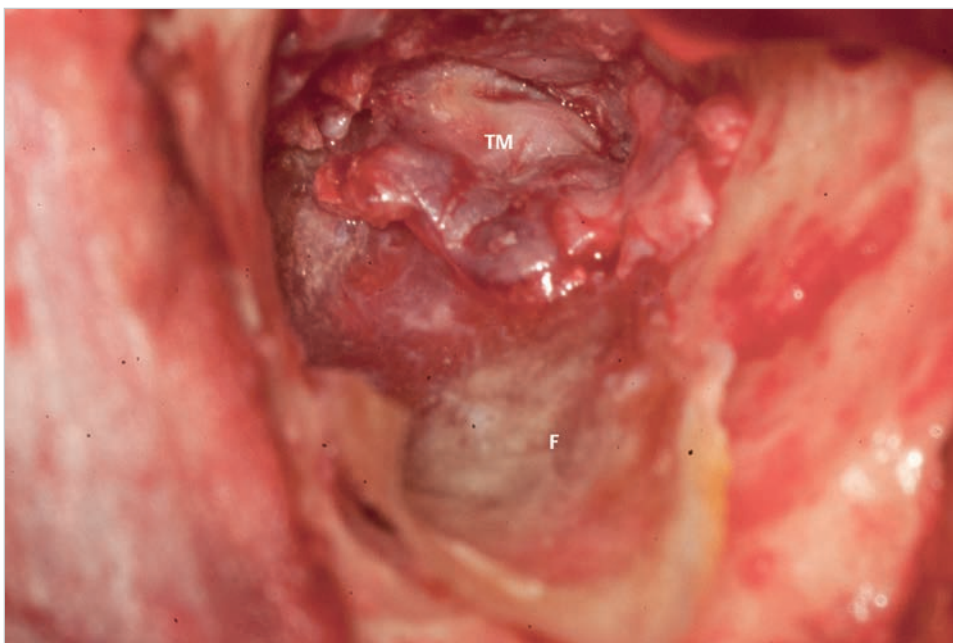


Fig. 10.27 The final shape of the cavity is shown. The small area of the middle fossa dura exposed in the tegmen is covered with bone paste. The final shape of the cavity is shown. F, fascia; TM, tympanic membrane.

Case 10.3 (Right Ear)

See ▶ Fig. 10.28, ▶ Fig. 10.29, ▶ Fig. 10.30, ▶ Fig. 10.31, ▶ Fig. 10.32.

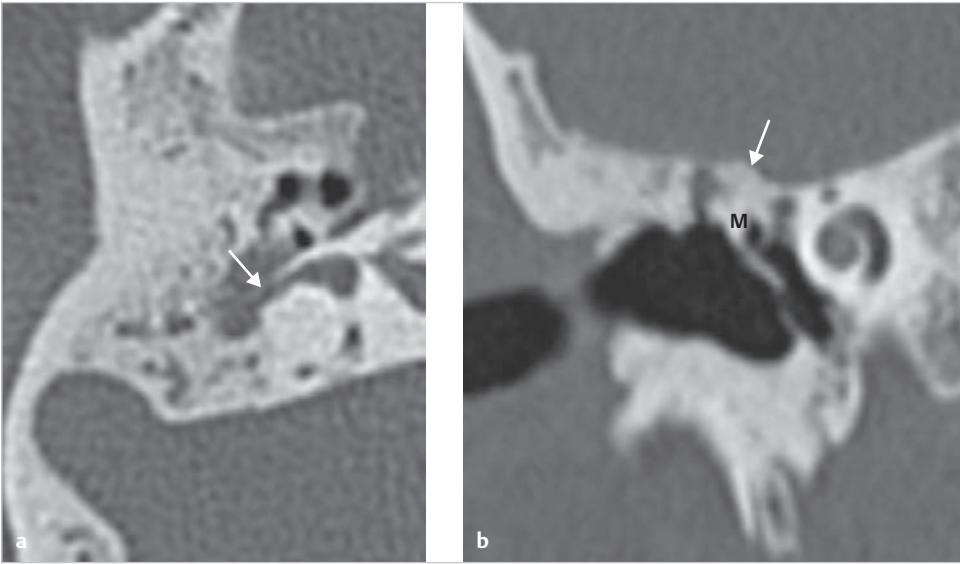


Fig. 10.28 A case of cholesteatoma with labyrinthine fistula. The axial CT shows presence of a large fistula in the lateral semicircular canal (a). In the coronal section, complete fixation of the head of the malleus by tympanosclerosis is demonstrated. In spite of such severe change, the tympanic cavity is well aerated (b), and hearing stays usable due to myringostapediopexy. M, malleus.

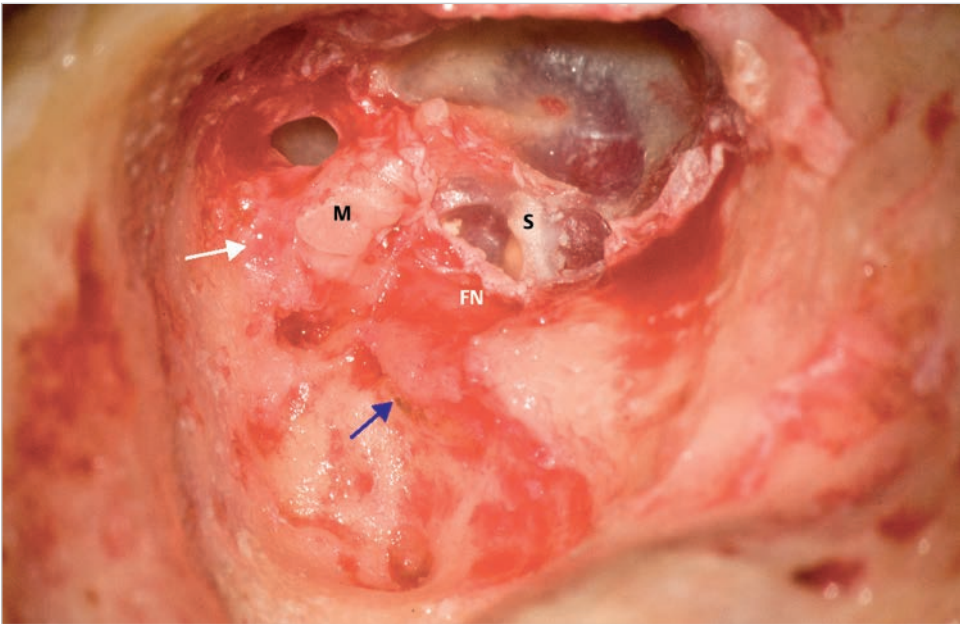


Fig. 10.29 Canal wall down mastoidectomy is carried out, to remove cholesteatoma in the mastoid. During dissection, a large fistula is identified in the lateral semicircular canal (blue arrow). Since scar tissue filling the semicircular canal prevents it to be opened, the inflamed skin covering the fistula is totally removed. The head of the malleus is fixed with tympanosclerotic plaque (white arrow). FN, facial nerve; M, malleus; S, stapes.

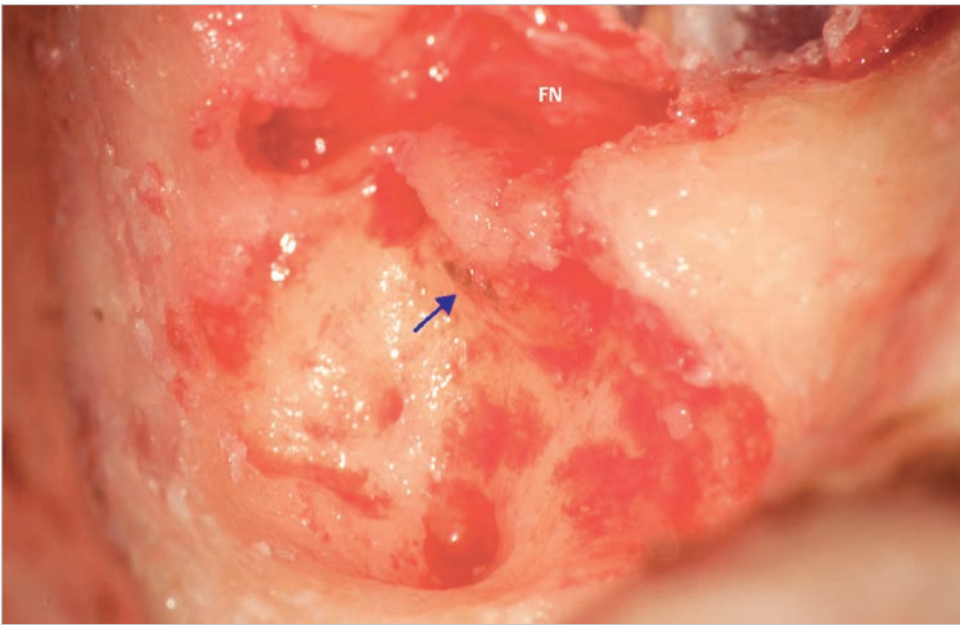


Fig. 10.30 In higher magnification, the lateral semicircular canal filled with scar tissue is shown (arrow). FN: facial nerve.

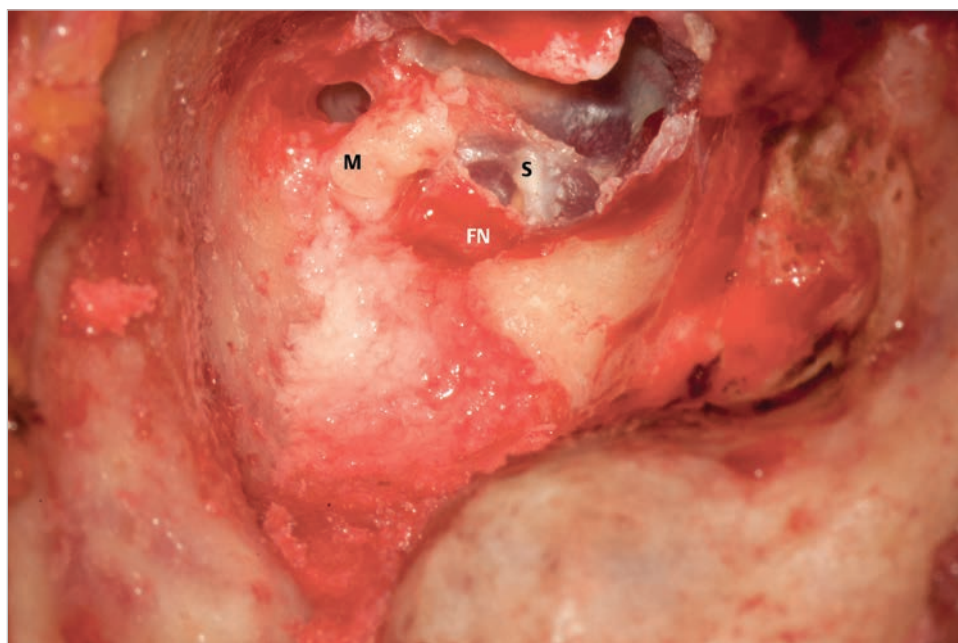


Fig. 10.31 Bone paste is applied to cover the medial wall of the mastoid including the fistula. FN, facial nerve; M, malleus; S, stapes.

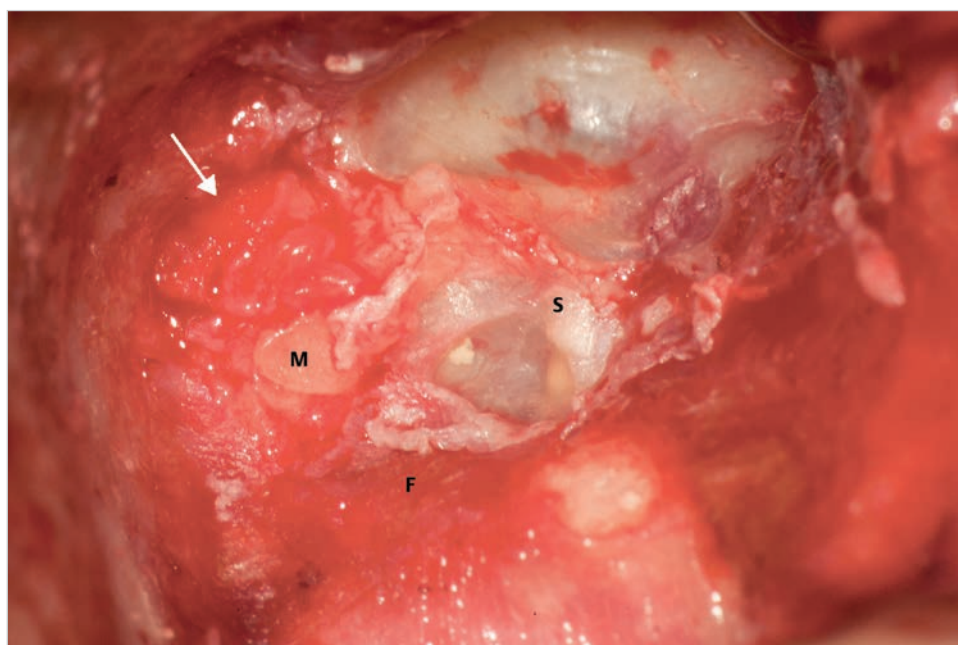


Fig. 10.32 The final shape of the cavity around the tympanic membrane is shown. The skin covering the stapes is left untouched, and on opening to the supratubal recess anteriorly to the head of the malleus is obliterated with a piece of cartilage and fascia (*arrow*). The medial wall of the cavity and bone paste is covered with a large piece of fascia placed under the head of the malleus. F, fascia; M, malleus; S, stapes.

Case 10.4 (Right Ear)

See ► Fig. 10.33, ► Fig. 10.34, ► Fig. 10.35, ► Fig. 10.36, ► Fig. 10.37, ► Fig. 10.38, ► Fig. 10.39, ► Fig. 10.40, ► Fig. 10.41, ► Fig. 10.42, ► Fig. 10.43.



Fig. 10.33 A case of cholesteatoma complicated by labyrinthine fistulas in both the superior and the lateral semicircular canals, and with widely eroded tegmen in the mastoid. Canal wall down mastoidectomy revealed presence of cholesteatoma filling the mastoid.

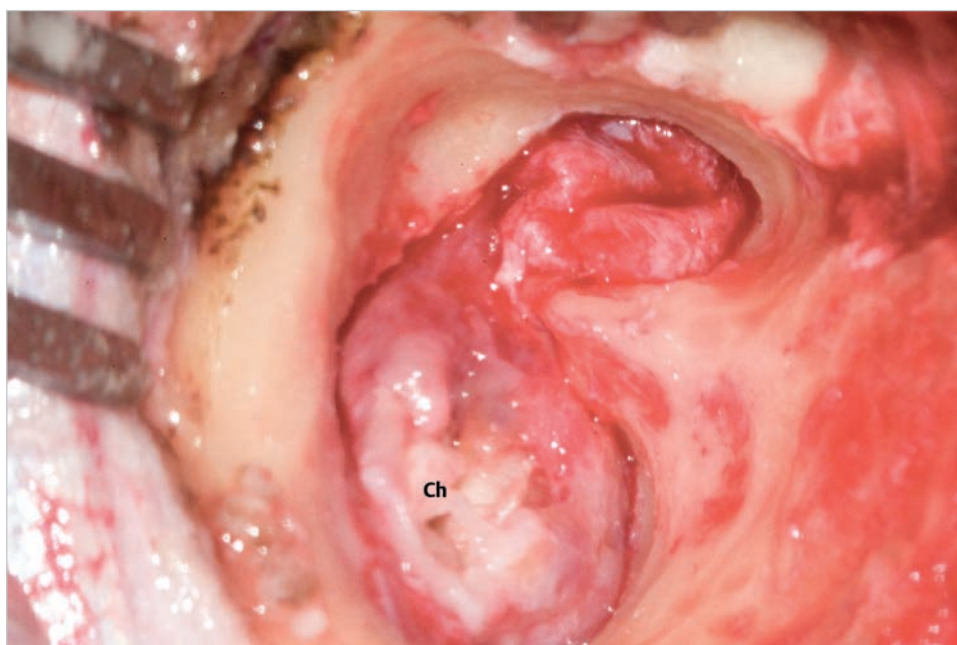


Fig. 10.34 Debulking of cholesteatoma is carried out, and the posterior wall is removed and canal wall down procedure is advanced medially. Ch, cholesteatoma.

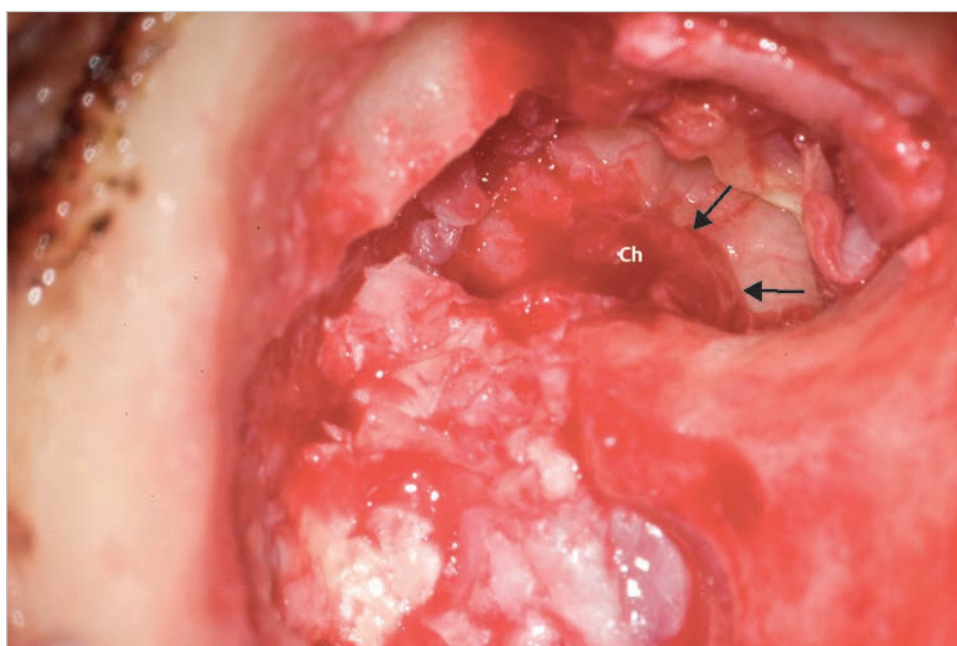


Fig. 10.35 The tendon of the tensor tympani muscle is cut to open the tympanic cavity fully to expose cholesteatoma descending to the posterior mesotympanum (arrows). Ch, cholesteatoma.



Fig. 10.36 The cholesteatoma matrix covering the area of the oval window is seen (*arrow*). FN, facial nerve; RWN, round window niche.

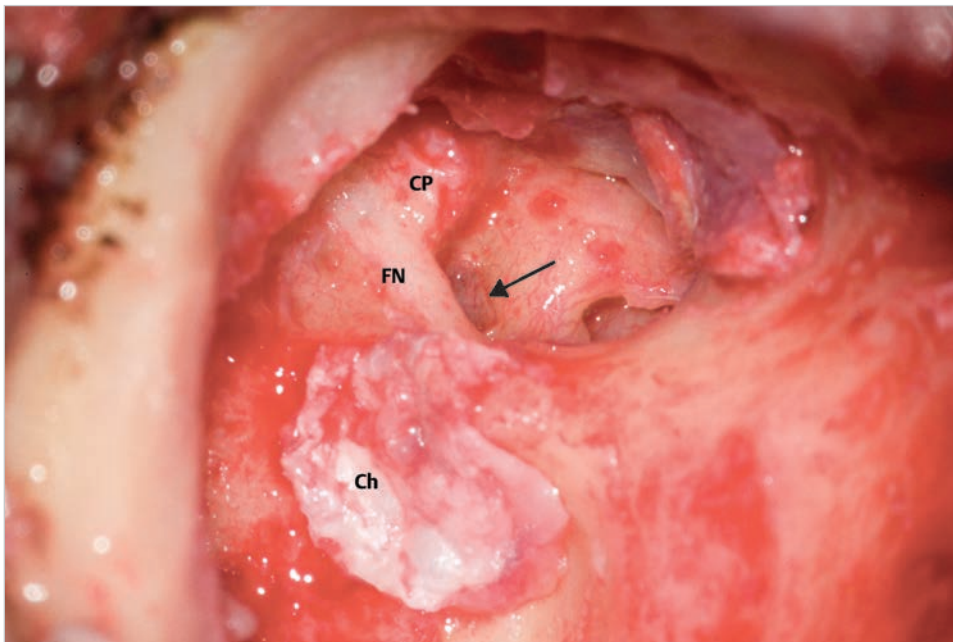


Fig. 10.37 The cholesteatoma is removed from the tympanic cavity. The facial nerve maintains its bony coverage. The footplate of the stapes is clearly seen (*arrow*). To preserve hearing, a piece of cholesteatoma matrix covering the fistulae of semicircular canals are left untouched. Ch, cholesteatoma; CP, cochleariform process; FN, facial nerve.



Fig. 10.38 Further dissection of cholesteatoma from the mastoid revealed extensively exposed middle fossa dura. Ch, cholesteatoma; MFD, middle fossa dura.

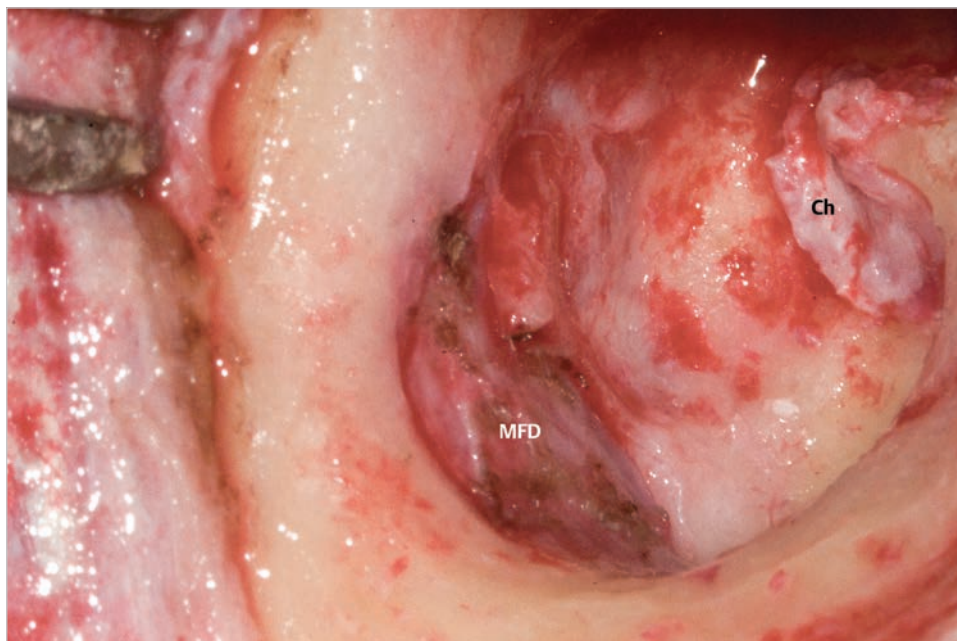


Fig. 10.39 To kill the matrix covering the dura, it is extensively coagulated with bipolar cautery. Use of a monopolar cautery is strictly prohibited since it may cause a perforation. The procedure simultaneously stops bleeding from the dura. Ch, cholesteatoma; MFD, middle fossa dura.

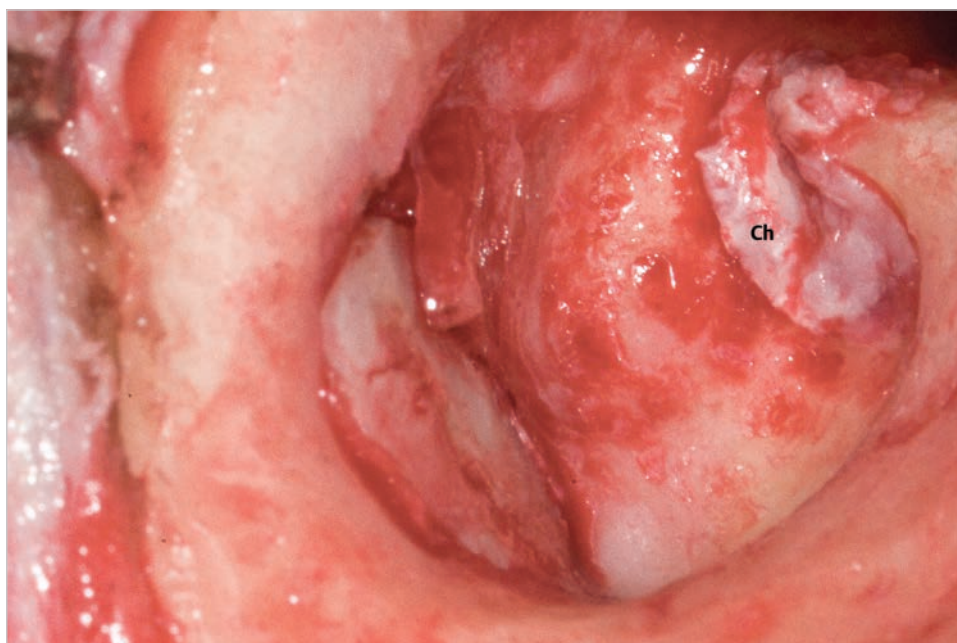


Fig. 10.40 The middle fossa dura is gently detached from the middle fossa plate, and a large piece of cartilage is inserted between the bone and the middle fossa dura. Ch, cholesteatoma.

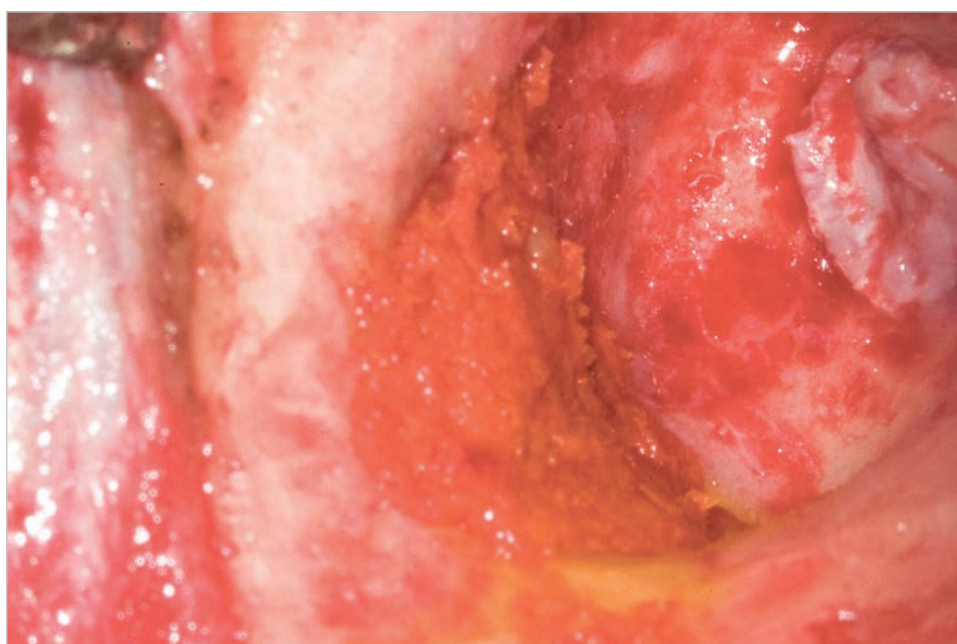


Fig. 10.41 The cartilage is covered with bone paste.

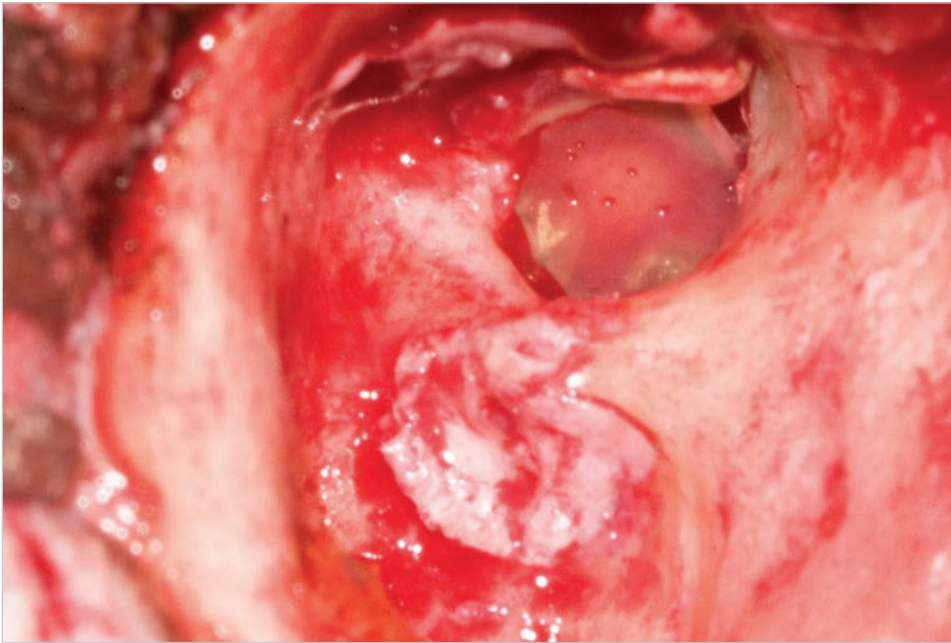


Fig. 10.42 A small piece of Silastic sheeting is placed in the tympanic cavity.

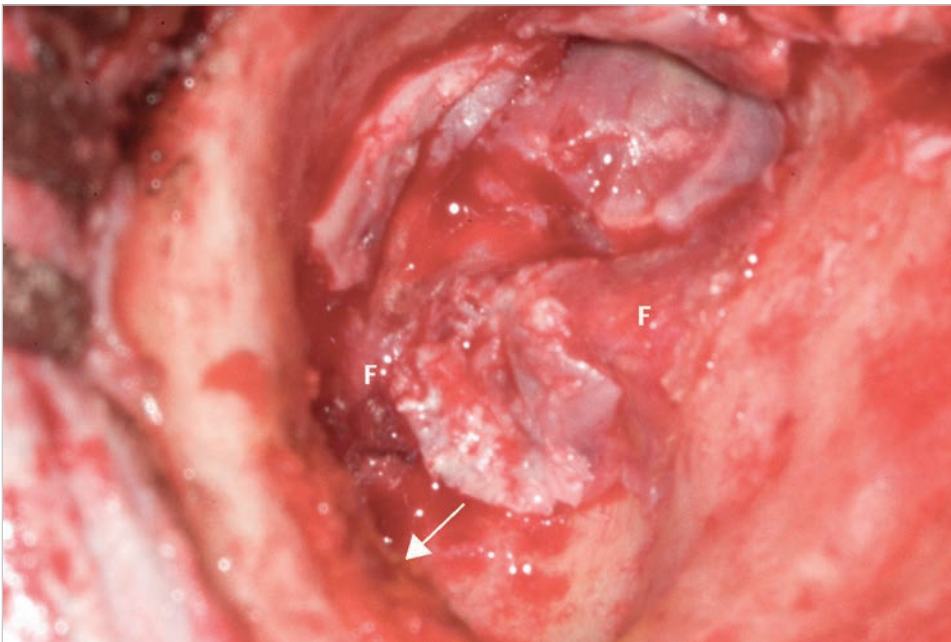


Fig. 10.43 Two pieces of temporalis fascia are grafted underlay, and the tympanomeatal flap is replaced over the fascia. Extension of fascia should cover as much area of the medial wall of the cavity as possible. The skin over the labyrinthine fistulae should be left uncovered. The bone paste (arrow) will be covered with the other piece of fascia. F, fascia.

10.3 Facial Nerve Paralysis

Facial nerve paralysis can be a complication with cholesteatoma, due to infection of the exposed nerve or secondary to compression by the cholesteatoma. In the majority of cases, removal of the cholesteatoma with cleaning of the infected tissue is sufficient for the paralysis to resolve. It is very rare to find fibrosis or thinning of the nerve. In these cases, facial nerve reconstruction varies from end-to-end anastomosis with rerouting to nerve grafting, according to the degree of injury and length of the injured segment.

Our findings indicate that grafting the nerve early, within 12 months from the onset of the facial nerve deficit, gives better result than the delayed surgery, irrespective of preoperative facial nerve function. Therefore, it seems better to reconstruct the facial nerve if severe palsy is still present a considerable time after cholesteatoma removal. On the other hand, since no patient who has undergone nerve reconstruction has shown

recovery better than Grade III on the House–Brackmann grading system, early reconstruction of the nerve is indicated only when the palsy remains worse than Grade III after cholesteatoma removal.

10.4 New Bone Formation

In some cases of cholesteatoma, an osseous structure is formed near the cholesteatoma matrix. This condition may occasionally occur lateral to some part of the matrix, concealing it from the surgeon's view (► Fig. 10.44). A high index of suspicion and careful inspection of the middle ear is required in that case. The remnant of cholesteatoma may eventually cause relapse of the disease in a more complicated form. Preoperative high-resolution computed tomography (CT) is helpful in diagnosing this condition. During surgery, the newly formed osseous tissue is removed and underlying pathology is managed.

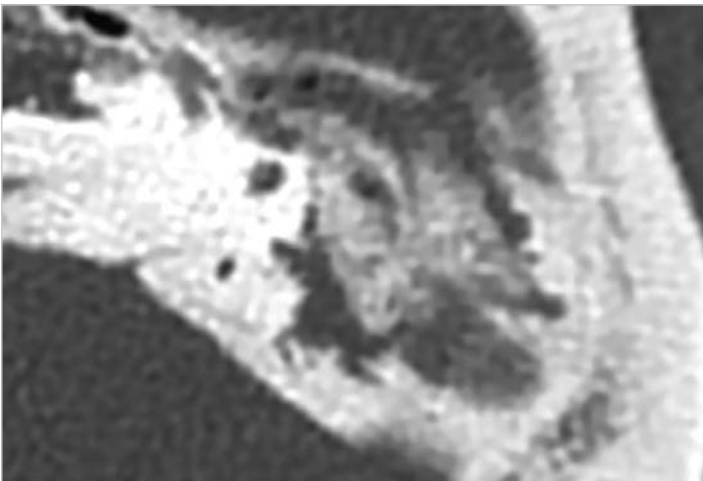


Fig. 10.44 Axial CT image of cholesteatoma with new bone formation (*left ear*). A large newly formed bone is identified in the cholesteatoma. Cholesteatoma matrix is identified under the bone during surgery. Failure of complete removal of this bone will cause relapse of the disease.

10.5 Meningoencephalic and Dural Herniation

Meningoencephalic herniation is a condition in which meningeal or encephalic tissue is herniated into the middle ear through a bony defect in the tegmen of the mastoid or the attic (► Fig. 10.45). The bony defect is always accompanied by a dural defect that allows brain tissue to get into the middle ear. Causes of the bony defect in the tegmen are infection, surgery, head trauma, and congenital defects. However, no satisfactory explanation has been given for the dural defect, except for surgical problems.

The clinical significance of this herniated tissue is in its potential sequelae such as cerebrospinal fluid (CSF) leak, epilepsy, and intracranial infection. Therefore, once meningoencephalic herniation is suspected, surgical correction is required. Clinical presentation of meningoencephalic herniation may include the sequelae mentioned above and a pulsating mass in the middle ear. In such cases, diagnosis of this condition may not be difficult. However, the commonest symptoms, conductive or mixed hearing loss with a draining ear or a serous otitis media, are atypical and make correct diagnosis difficult, especially in the previously operated mastoid.

In our experience, 5% of revision canal wall down mastoidectomy are complicated by either meningoencephalic or dural herniations. A small herniation (<1 cm²) can be pushed back intracranially after coagulating it with bipolar (► Fig. 10.46), and a piece of cartilage then inserted beneath the bone to ensure repositioning of the dura (► Fig. 10.47). Bone paste is applied over the cartilage (► Fig. 10.48), and the area is covered with fascia (► Fig. 10.49).

Herniation larger than that, and cases with CSF leak either preoperatively and intraoperatively, is managed with subtotal petrosectomy combined with obliteration of the middle ear with abdominal fat. The procedure is described in Chapter 11 (see also Case 11.14).



Fig. 10.45 Meningoencephalic herniation.

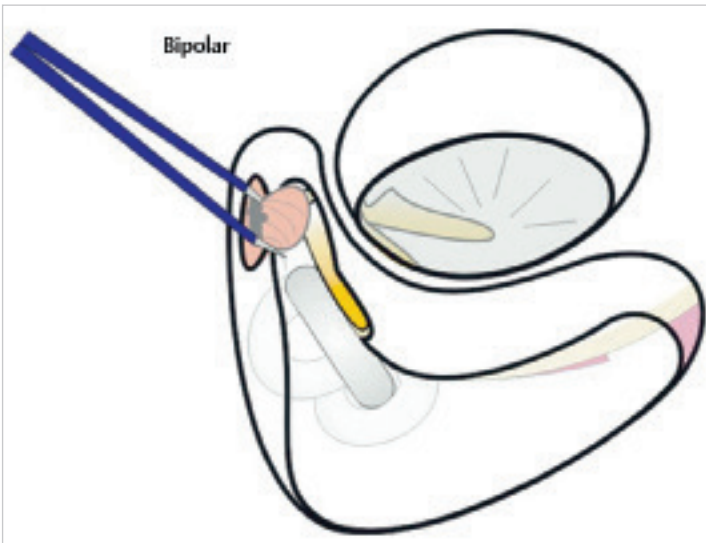


Fig. 10.46 Coagulation of the herniated tissues.

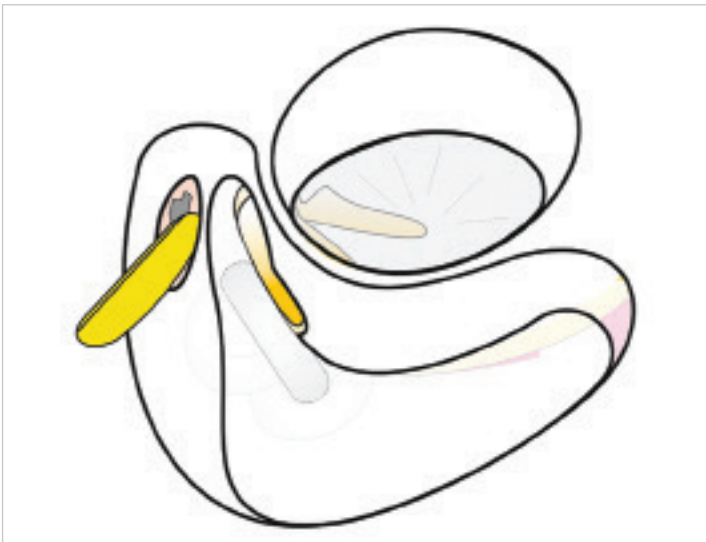


Fig. 10.47 Cartilage is inserted beneath the middle fossa plate.

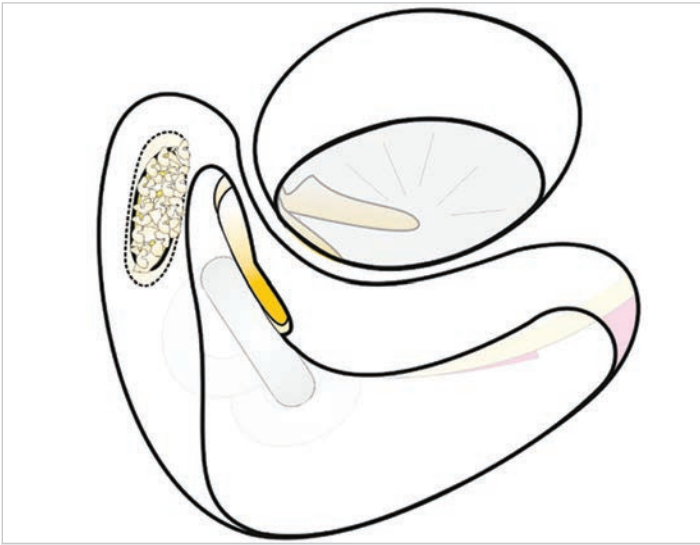


Fig. 10.48 Bone paste is applied over the cartilage.

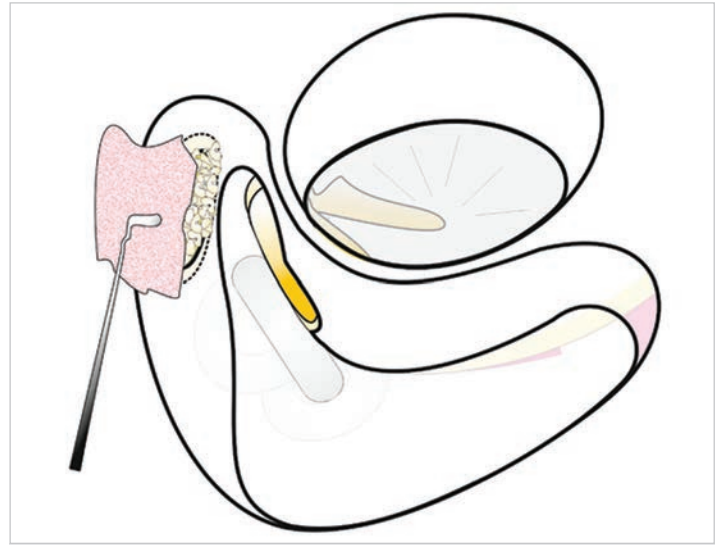


Fig. 10.49 The area is covered with fascia.

Case 10.5 (Right Ear)

See ► Fig. 10.50, ► Fig. 10.51, ► Fig. 10.52, ► Fig. 10.53, ► Fig. 10.54, ► Fig. 10.55, ► Fig. 10.56.

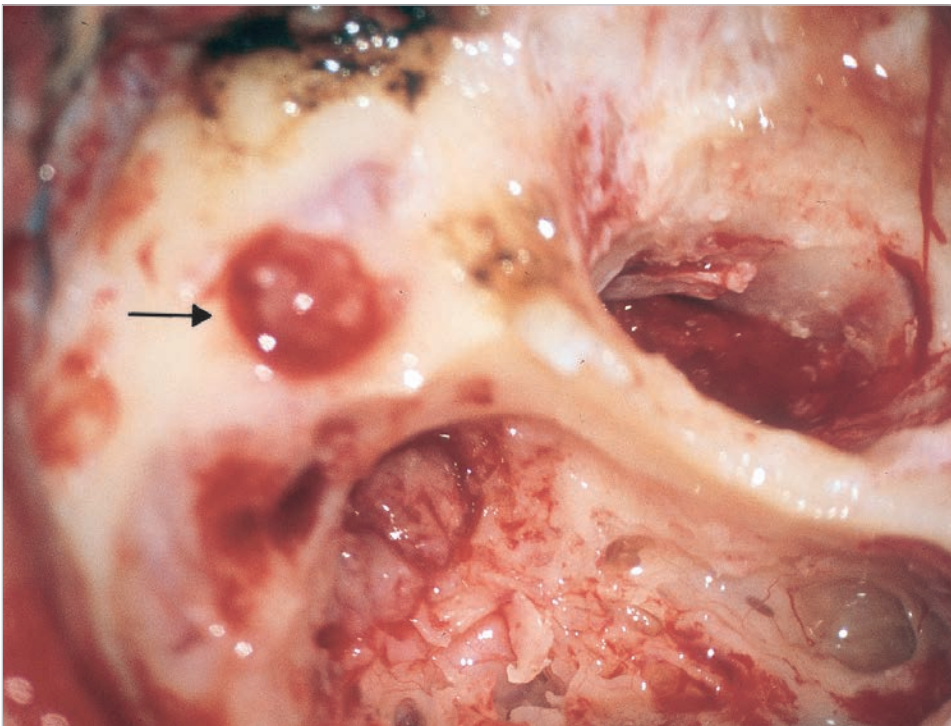


Fig. 10.50 A case of small meningoencephalic herniation repair is shown. Mastoidectomy is carried out and the antrum is opened. Granulation and scar tissue filling the antrum are seen. The other dural herniation is seen on the surface of cortical bone (arrow).



Fig. 10.51 The antrum is further opened taking care not to damage the meningoencephalic herniation with a burr.

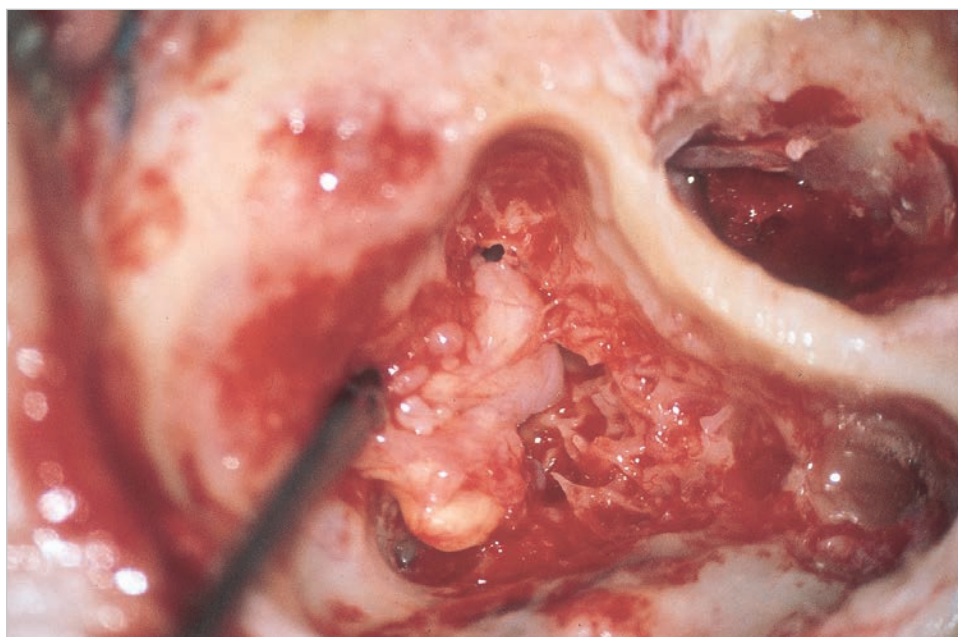


Fig. 10.52 Scar and granulation tissue around the meningoencephalic herniation is carefully dissected.

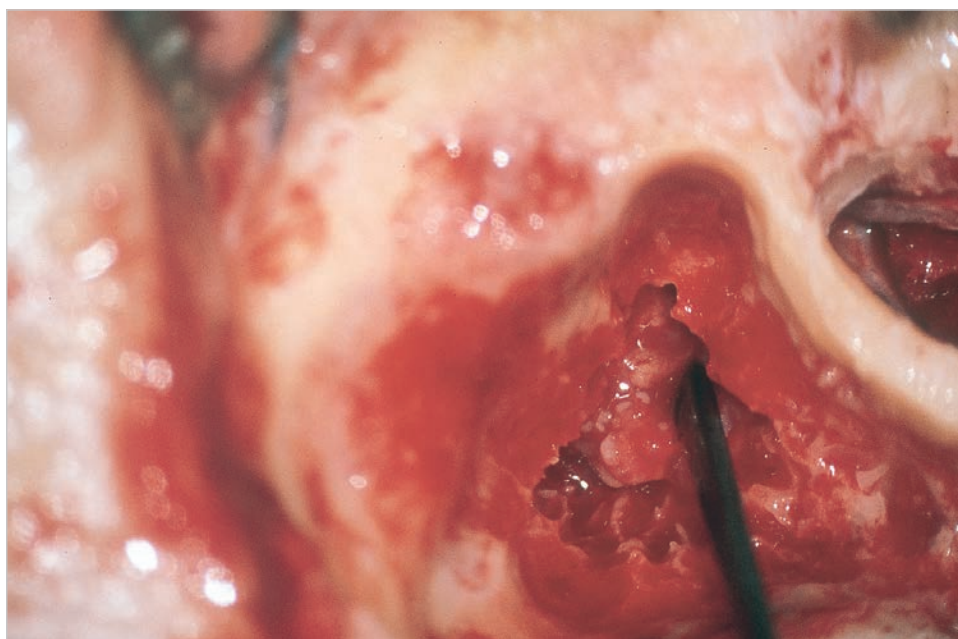


Fig. 10.53 Herniated brain tissue is seen in the tegmen of the antrum.



Fig. 10.54 With a bipolar coagulator, the tissue is coagulated and shrunk to push back into the cranium. A bony defect caused the herniation is seen in the tegmen.

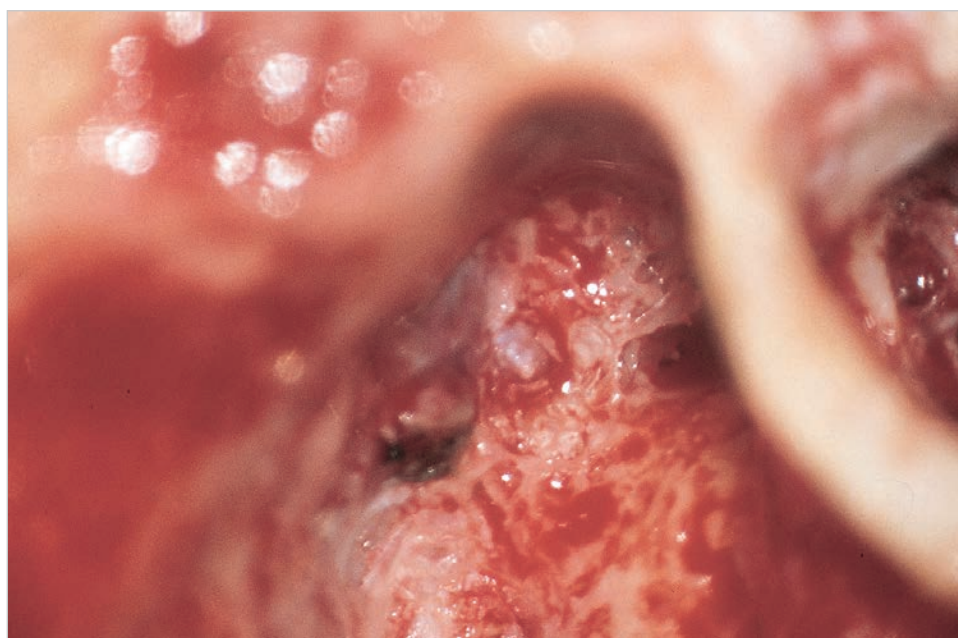


Fig. 10.55 Thin and eroded edges of the bone defect are removed for following reconstruction.

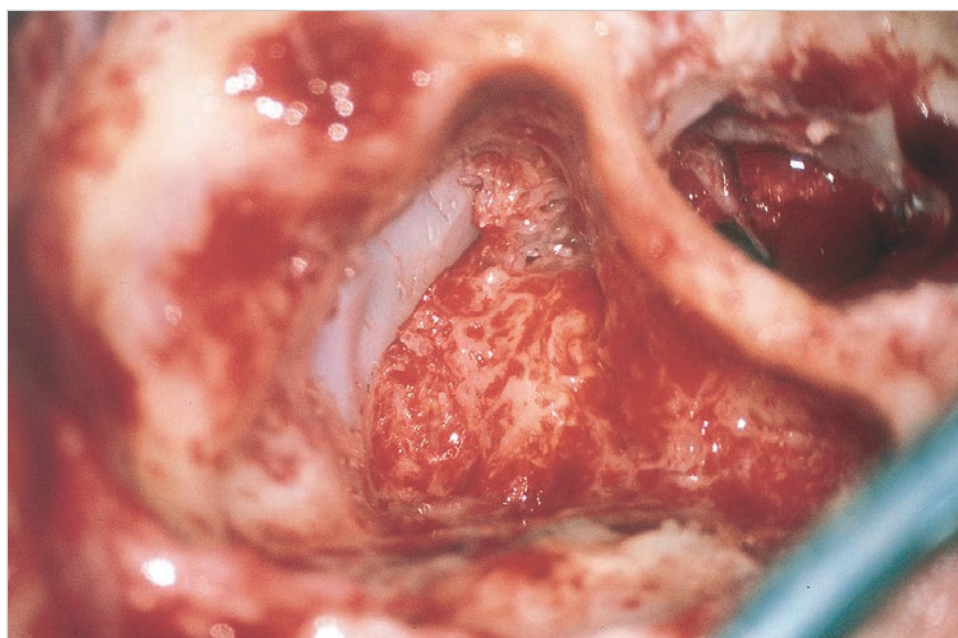


Fig. 10.56 The bony defect is repaired by inserting a thick cartilage between the tegmen and the middle fossa dura. The cartilage is further covered with the temporalis fascia.

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11 Obliteration of the Middle Ear (Subtotal Petrosectomy) in Cholesteatoma Surgery

Indications

- Cholesteatoma in dead ear.
- Cholesteatoma with heavily infiltrated labyrinth.
- Unilateral advanced cholesteatoma with mental retardation.
- Canal wall down cavity with intractable inflammation with no serviceable hearing.
- Draining ear with no serviceable hearing with multiple previous surgeries.
- Recurrent cholesteatoma with huge mastoid aeration.
- Extensive exposure of middle fossa dura.
- Cholesteatoma with large meningoencephalic herniation.
- Major tear of the dura during surgery with ample cerebrospinal fluid (CSF) leakage.
- Cholesteatoma or canal wall down cavity with poor bilateral bone conduction necessitating cochlear implantation.

In some patients, obliteration of the middle ear (subtotal petrosectomy) using abdominal fat with blind sac closure of the external auditory canal and closure of the eustachian tube is reasonable, or even necessary.

In case of cholesteatoma in dead ear, the only concern of that ear is to avoid recurrence. If the technique is properly executed, subtotal petrosectomy is an ultimate solution to eliminate any possibility of recurrence.

Even though there is some residue of bone conduction, heavy erosion of the labyrinth makes leaving matrix on it difficult. It eventually further invaginates into labyrinth, or causes labyrinthitis to make situation more complicated. In such cases, the labyrinth is drilled and the cavity is packed with abdominal fat.

In some advanced cases of unilateral cholesteatoma with mental retardation, maintenance of the open cavity for life is impractical. In such cases, closure of the ear might be a good solution. Meticulous audiologic examination using objective measures such as auditory brainstem response (ABR) and auditory steady-state response (ASSR) is required before surgery to verify good contralateral hearing.

A chronically inflamed open cavity with nonserviceable hearing is one of the most common candidates for obliteration of the middle ear. The patient is annoyed with multiple surgical interventions, repetitive odorous otorrhea, or frequent episode of vertigo due to thermal stimulation. This technique frees the patients from such a troublesome state, reduce frequency of office visits, and eventually improves the quality of life.

The technique can be applied even in cases with intact bony canal wall if the patient still has an inflamed ear with no recovery of hearing after multiple ear surgery.

In some advanced cases of recurrent cholesteatoma with huge pneumatization, achievement of a trouble-free canal wall down cavity using partial obliteration technique with bone paste and/or vascularized flaps is not practical. In such cases, obliteration of the middle ear can be one of the therapeutic choice, depending on contralateral hearing and the patient's age.

Cholesteatomas with unmanageable exposure of the dura, and presence of a large labyrinthine fistula with no possibility of good hearing are other indications for subtotal petrosectomy.

A CSF leakage from a tear of the dura may occur as a surgical complication. If the leak is severe, obliteration of the cavity after repairing the dural defect with either fascia or piece of muscle is indicated. To reduce the risk of possibly lethal meningitis, air cells are intensively removed to eliminate possible pathway for CSF.

In the majority of large meningoencephalic herniation with cholesteatoma can be treated with combined extradural middle fossa and transmastoid approach. However, in some cases of very large meningoencephalic herniation reconstruction of the bone erosion is impractical, and obliteration of the middle ear after reducing the herniation and dissecting the cholesteatoma matrix is a safer choice.

The obliteration technique is also applied to cochlear implants in some special situations of cholesteatoma surgery (see Chapter 12).

In the obliterating procedure, it is very important to remove all squamous epithelium within the cavity by carrying out meticulous dissection and correct drilling techniques. However, especially in cases of cholesteatoma with thin matrix covering the dura, remnant of such epithelium may eventually form residual cholesteatoma, and radiologic follow-up of the obliterated cavity with magnetic resonance imaging (MRI) using fat suppression and diffusion sequences is mandatory.

11.1 Surgical Steps to Close the External Auditory Canal

1. After the wide retroauricular incision that extends superior and inferior more anteriorly for better access and possibility to reflect the pinna, the external ear canal is identified (► Fig. 11.1).
2. The skin of the lateral part of the external ear canal is then circumferentially elevated for the width of about 1 cm. For elevation of the skin the microscope or loop glasses can be used for better visualization (► Fig. 11.2).
3. The external ear canal is now transected. Transection should not be performed too medially as the skin is thinner here, making dissection of the lateral part more difficult (► Fig. 11.3).
4. Now also the anterior part of the external ear canal is transected (► Fig. 11.4).
5. Anteriorly, the skin is loosened from the tragal cartilage using blunt scissors (► Fig. 11.5).
6. The skin of the lateral part of the external meatus is circumferentially loosened for about the width of 1 cm (► Fig. 11.6).
7. The skin of the external auditory canal is reflected laterally through the meatus to be sutured using resorbable surgical threads (4–0 Vicril; ► Fig. 11.7).
8. The closure of the second layer of the blind sac is performed using either tragal cartilage or an anteriorly pedicled subcutaneous flap (► Fig. 11.8, ► Fig. 11.9).

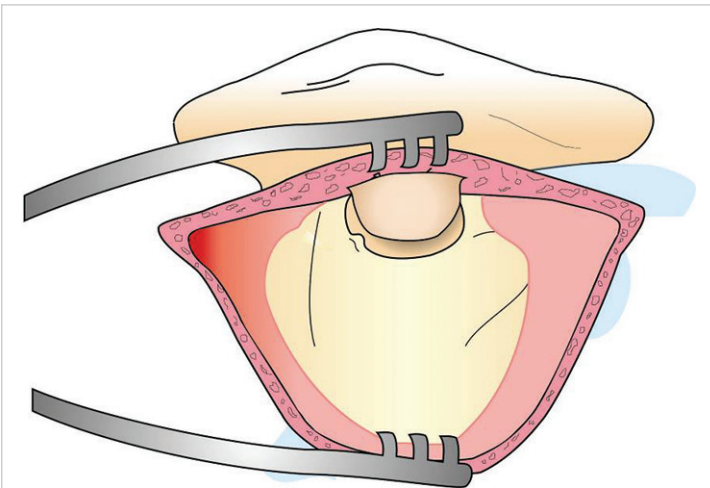


Fig. 11.1 A wide retroauricular C-shaped incision is performed.

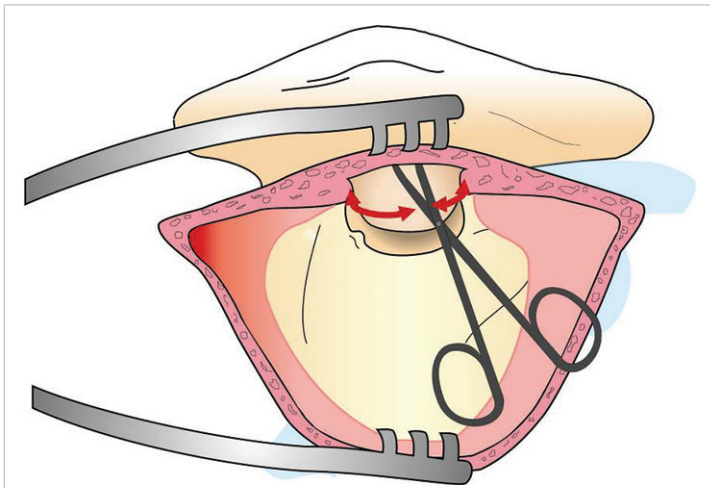


Fig. 11.2 Elevation of the lateral part of the external ear canal.

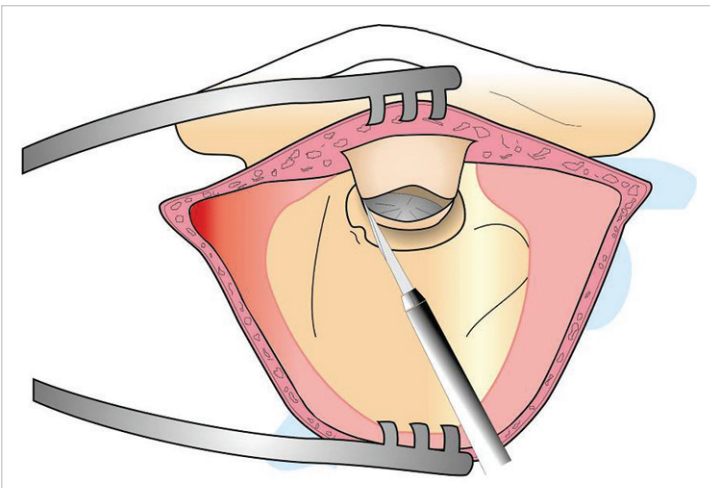


Fig. 11.3 Transection of the external ear canal.

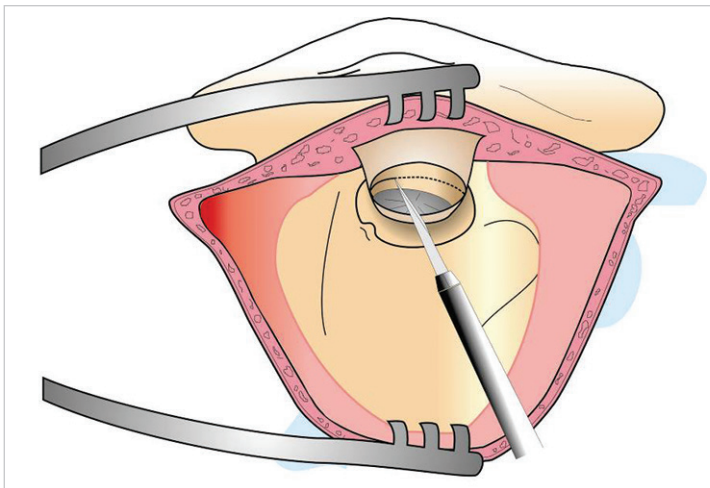


Fig. 11.4 Transection of the anterior wall of the external ear canal.

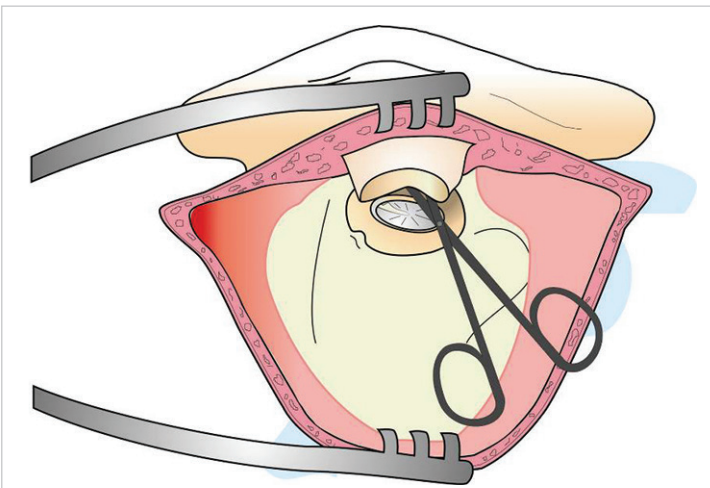


Fig. 11.5 Dissection of the anterior meatal skin from the tragal cartilage.

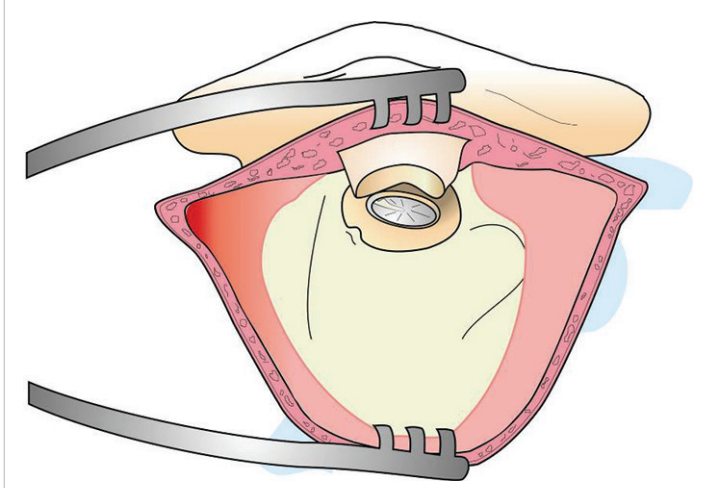


Fig. 11.6 The skin of the lateral part of the external meatus is circumferentially loosened.

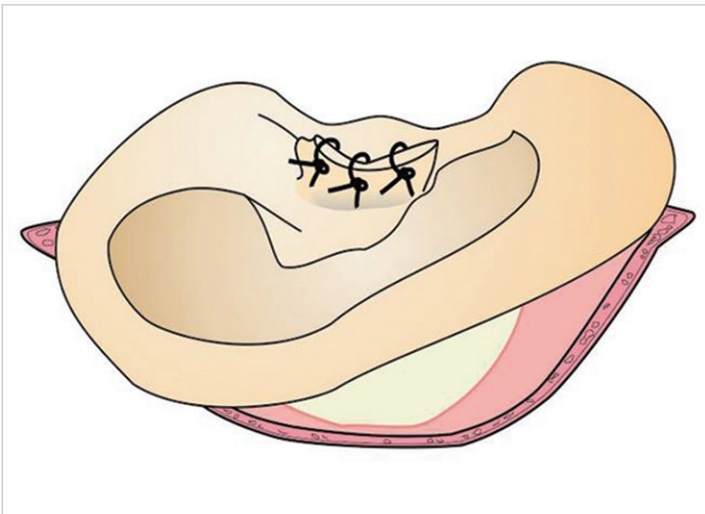


Fig. 11.7 The skin of the external auditory canal is reflected laterally through the meatus and sutured.

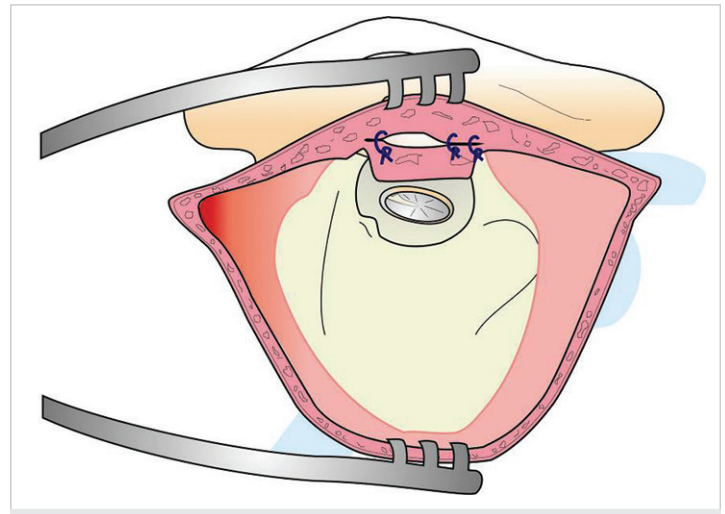


Fig. 11.8 Closure of the second layer of the blind sac is started.

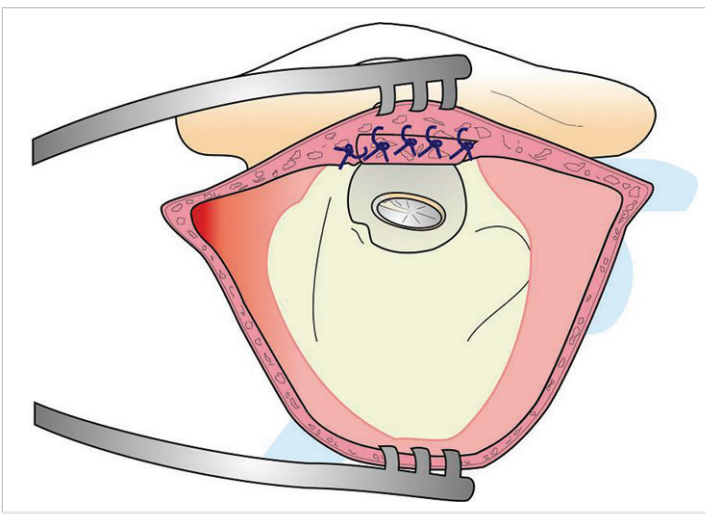


Fig. 11.9 The second layer of the blind sac is completely closed.

Case 11.1 (Right Ear): Blind Sac Closure of External Auditory Canal

See ► Fig. 11.10, ► Fig. 11.11, ► Fig. 11.12, ► Fig. 11.13, ► Fig. 11.14, ► Fig. 11.15, ► Fig. 11.16.

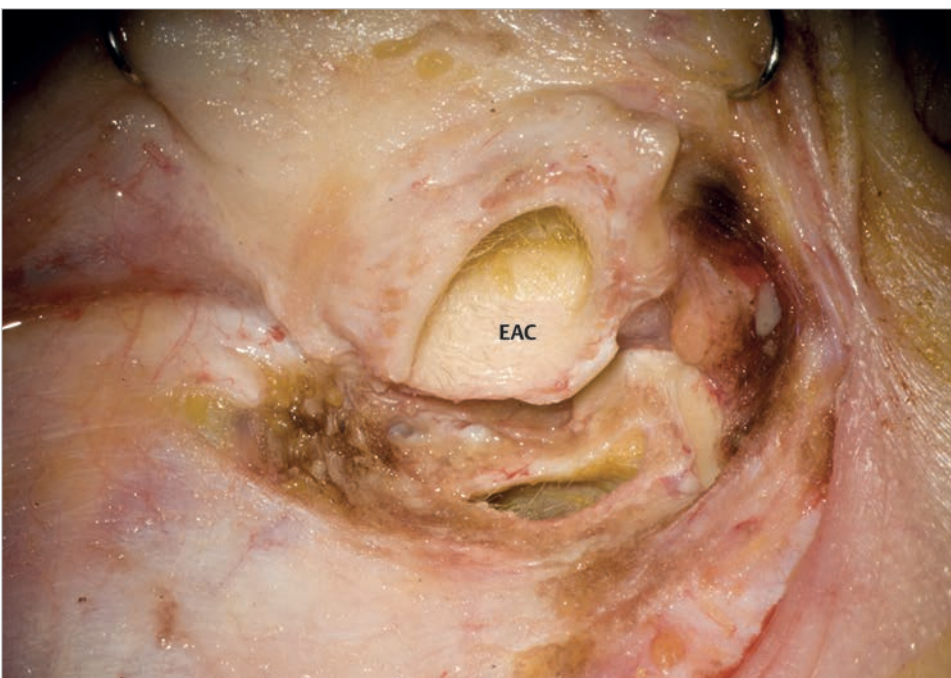


Fig. 11.10 After a wide retroauricular incision that covers whole external auditory canal for sufficient mobilization of the auricle, the skin and cartilage of the external auditory canal are transected circumferentially. The transection should be performed more laterally compared with usual middle ear surgery to make dissection of the lateral part easier. Note that the auricle is fully reflected anteriorly with skin hooks for the following procedures. EAC, external auditory canal.

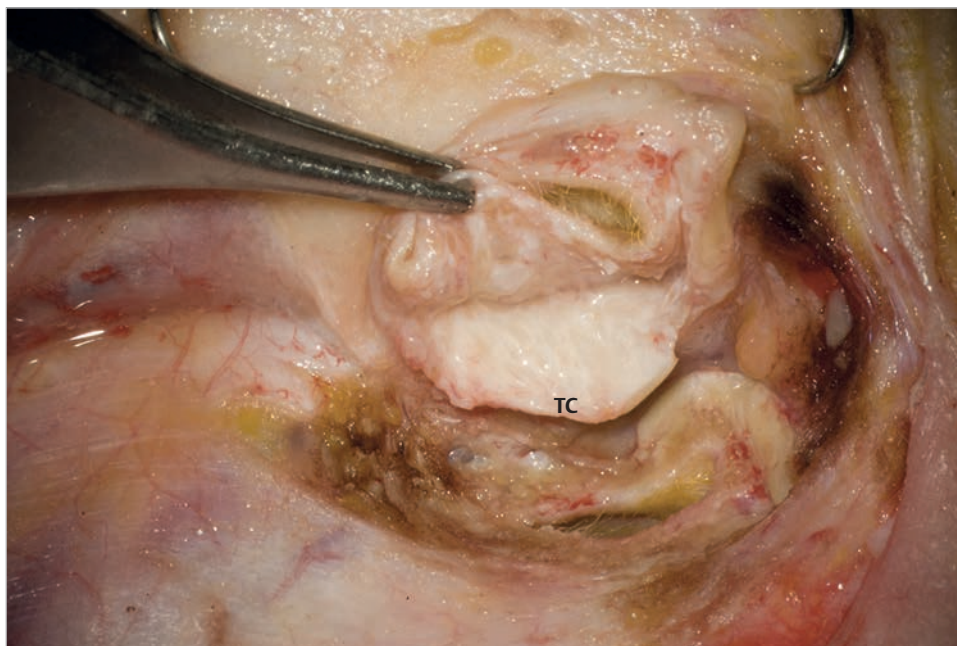


Fig. 11.11 The tragal cartilage is detached from the anterior wall of the bony meatus. The skin of the lateral part of the external meatus is then circumferentially dissected from surrounding tissue for about 1 cm. The cartilage and subcutaneous soft tissue are used for the second layer of the blind-sac closure. For precise dissection, use of microscope is recommended. TC, tragal cartilage.

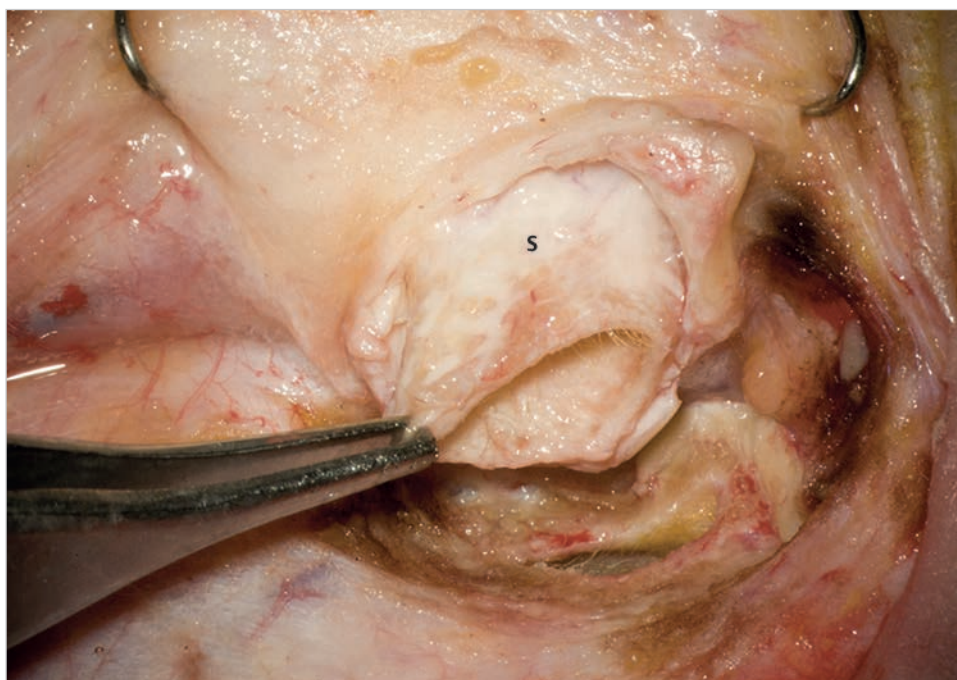


Fig. 11.12 The skin is loosened circumferentially and then everted laterally. A stitch placed on the medial end of this skin may be used to pull out to it to the external surface.



Fig. 11.13 The skin of the external auditory canal reflected laterally through the meatus is shown.

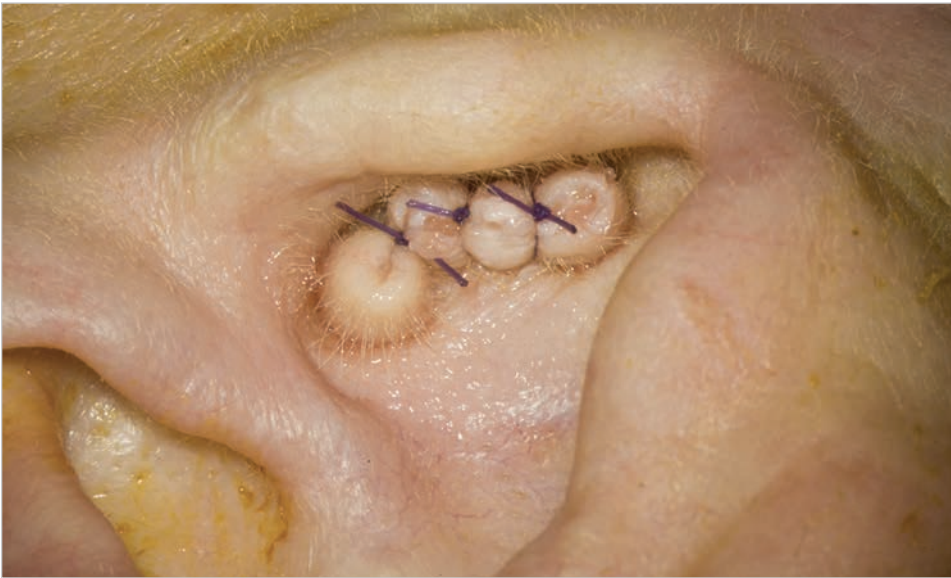


Fig. 11.14 Resorbable threads (4-0 Vicryl) are used in the external suture or the meatal skin. The everted tissue will shrink after some time and not be as visible as in this picture.

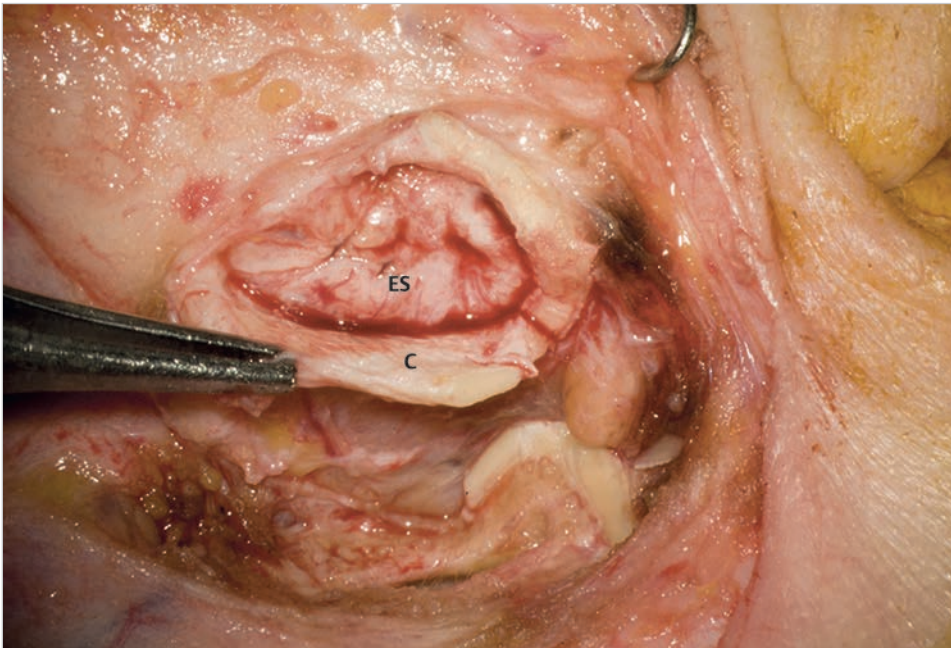


Fig. 11.15 Tragal cartilage (C) or an anteriorly pedicled subcutaneous flap dissected at the beginning of the procedure is used for the second layer of the blind-sac closure. The posterior flap is attached to the posterior rim of cartilage of the auricle. ES, internal surface of the everted skin.



Fig. 11.16 The blind-sac closure on the external auditory canal in two layers is completed.

Case 11.2 (Right Ear)

See ▶ Fig. 11.17, ▶ Fig. 11.18, ▶ Fig. 11.19, ▶ Fig. 11.20, ▶ Fig. 11.21, ▶ Fig. 11.22, ▶ Fig. 11.23, ▶ Fig. 11.24, ▶ Fig. 11.25, ▶ Fig. 11.26, ▶ Fig. 11.27, ▶ Fig. 11.28, ▶ Fig. 11.29, ▶ Fig. 11.30.

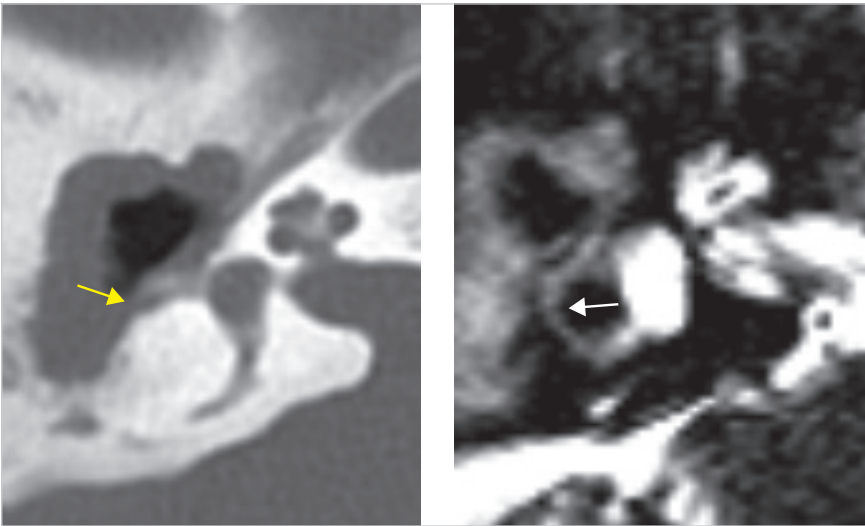


Fig. 11.17 A case of cholesteatoma in a contracted mastoid with large fistula in lateral and superior semicircular canals. As seen in the CT, cholesteatoma erodes the lateral semicircular canal extensively (*yellow arrow*). The T2-weighted image of MRI indicates decreased signal intensity of the canal (*white arrow*), implying some scarring process in the canal. In spite of such change, the bone conduction remains near normal.

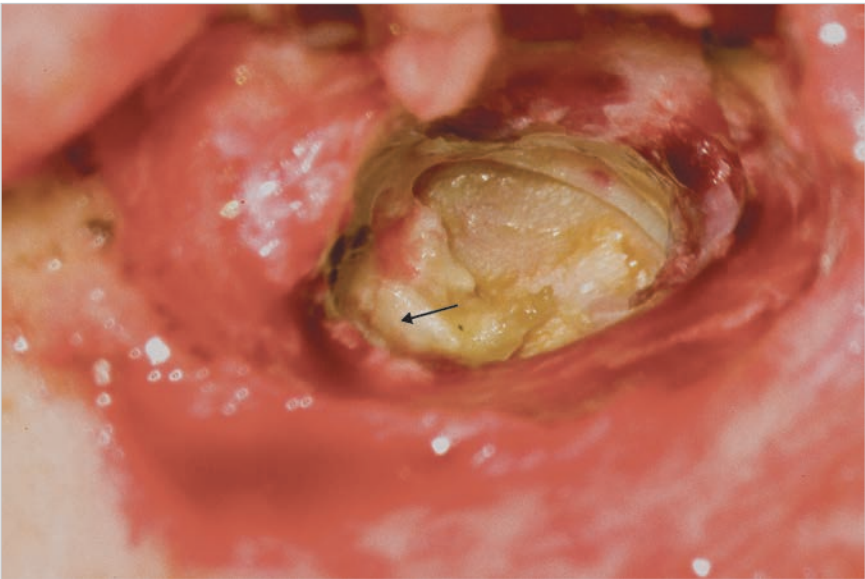


Fig. 11.18 The meatus is entered via retroauricular incision. The tympanic membrane is retracted, making the handle of the malleus prominent. Cholesteatoma is entered from the posterosuperior quadrant of the tympanic membrane (*arrow*).

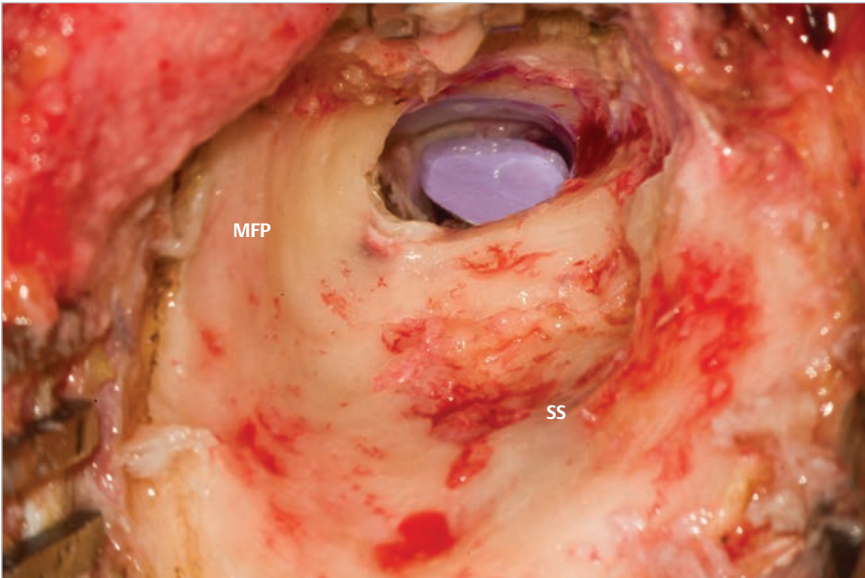


Fig. 11.19 To make maximal access to the middle ear, canal wall down mastoidectomy should be started in such way that the middle fossa plate (MFP) and the sigmoid sinus (SS) is identified first, and all sharp edges are removed. The drilling should gradually be advanced medially maintaining this wide access.

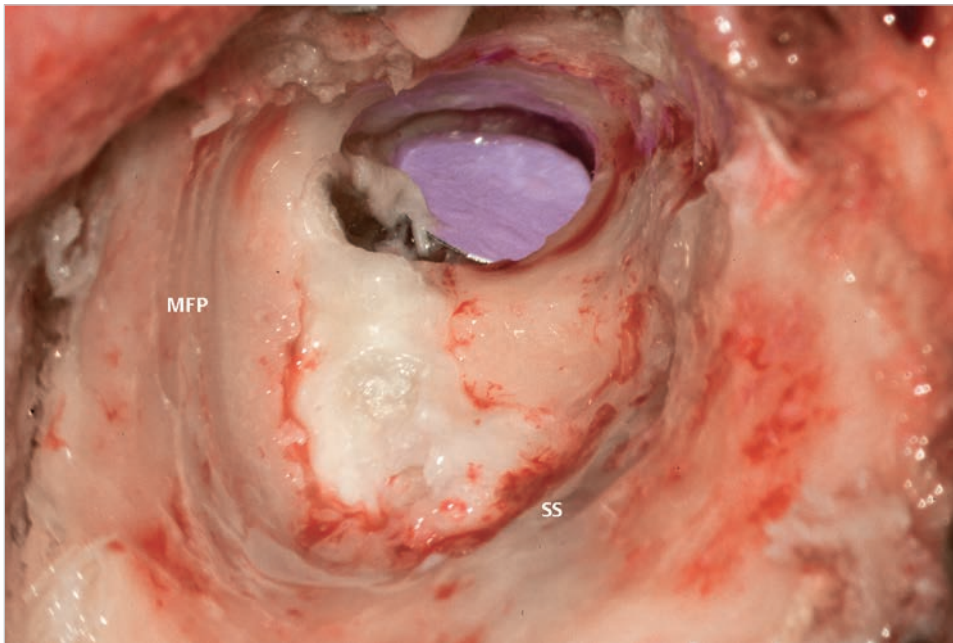


Fig. 11.20 The cholesteatoma filling poorly pneumatized mastoid is exposed. MFP, middle fossa plate; SS, sigmoid sinus.

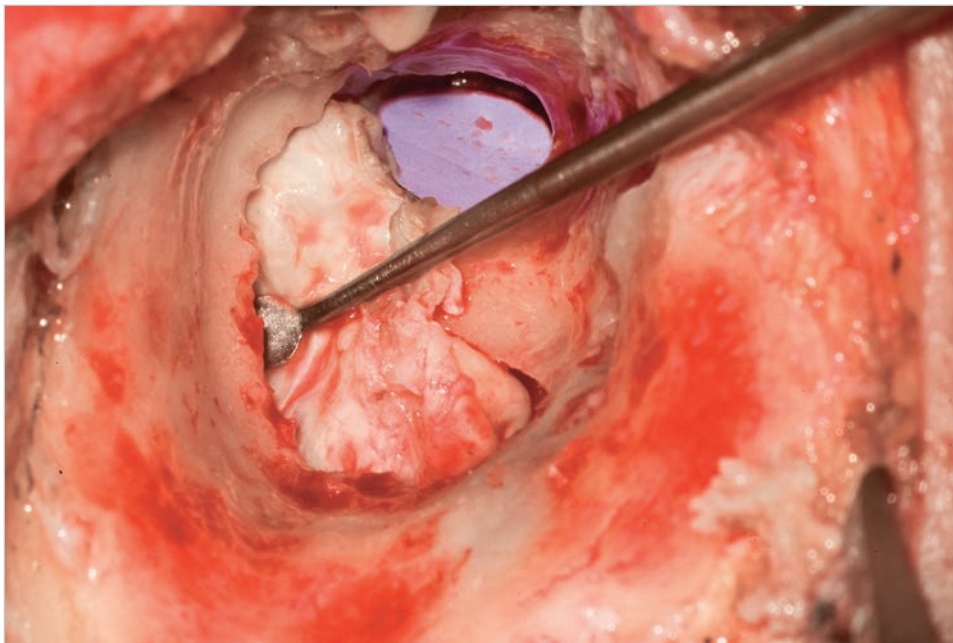


Fig. 11.21 Removal of cholesteatoma consists of evacuation of debris, careful dissection of matrix from the bone, and drilling of bone that covers cholesteatoma. Suspicious area of leaving matrix for infiltration should also be drilled.

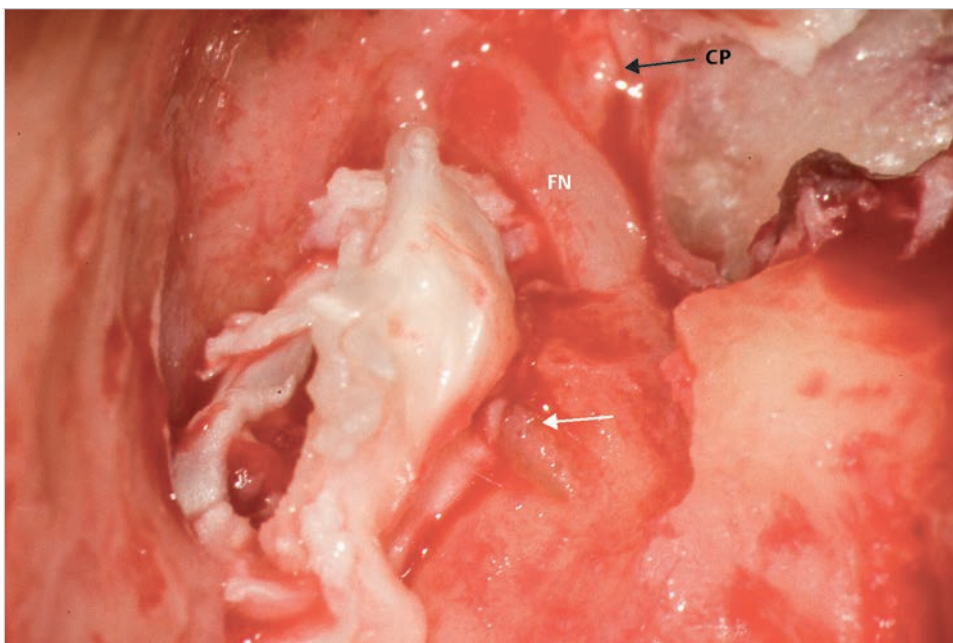


Fig. 11.22 Dissection of the matrix covering the lateral semicircular canal revealed scar tissue filling the canal (white arrow) as suspected in preoperative MRI. Note that the tympanic segment of the facial nerve is exposed extensively. The nerve runs just superomedially to the cochleariform process. CP, cochleariform process; FN, facial nerve.

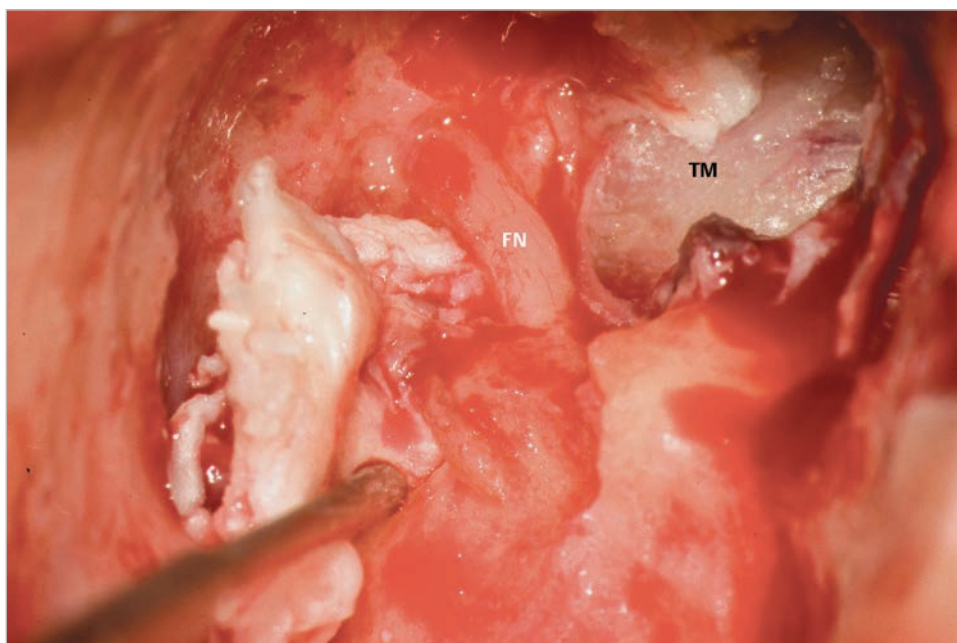


Fig. 11.23 Dissection of the matrix covering the lateral semicircular canal is advanced anteriorly. The scar tissue ends at the ampulla, and invagination of the matrix into the ampulla is identified. The tympanic membrane totally adherent to the medial wall is seen. FN, facial nerve; TM, tympanic membrane.



Fig. 11.24 Cholesteatoma is removed from the labyrinth. The ampulla of the lateral semicircular canal is filled with scar tissue (*yellow arrow*). A blue line of the ampulla of the superior semicircular canal (*black arrow*) can be identified superiorly to the opening. FN, facial nerve; TM, tympanic membrane.

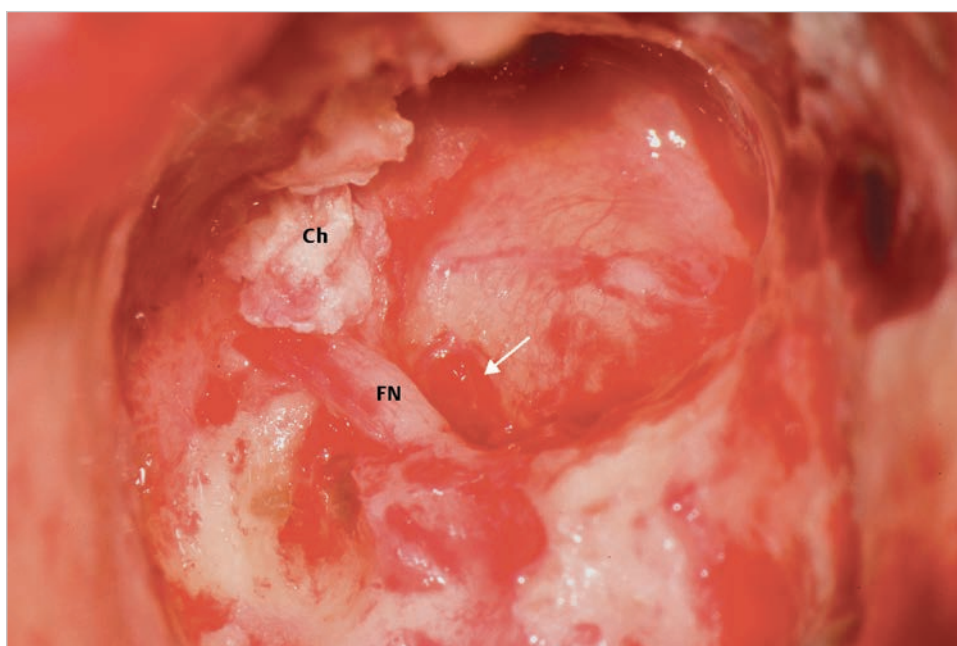


Fig. 11.25 The cholesteatoma covering the area of the stapes (*arrow*) is removed. The superstructure is totally eroded. Fistulae of superior and lateral semicircular canals are seen superiorly to the facial nerve. Ch, cholesteatoma; FN, facial nerve.

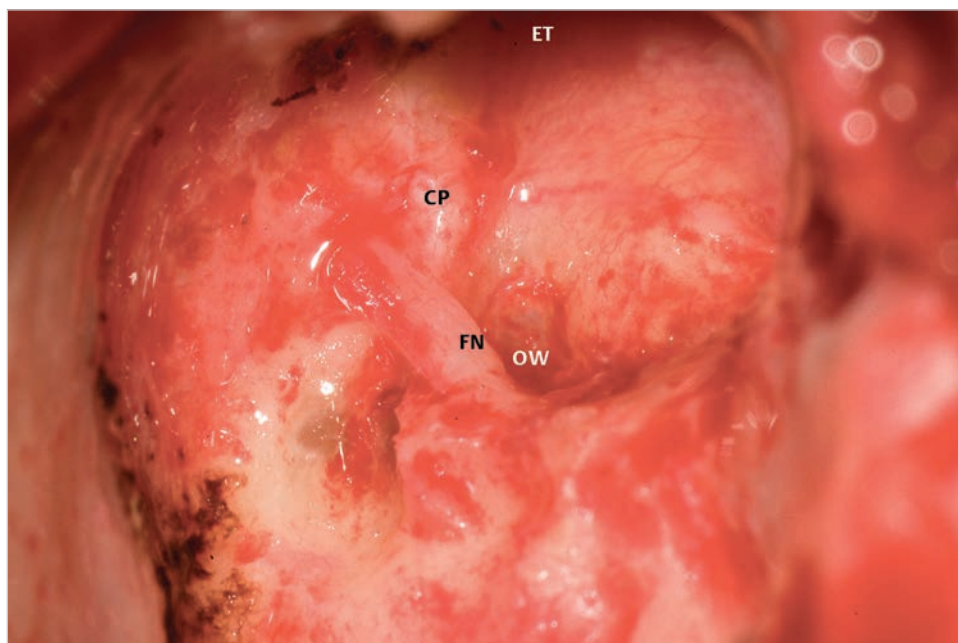


Fig. 11.26 The cholesteatoma is eradicated from the middle ear. CP, cochleariform process; ET, eustachian tube; FN, facial nerve; OW, oval window.

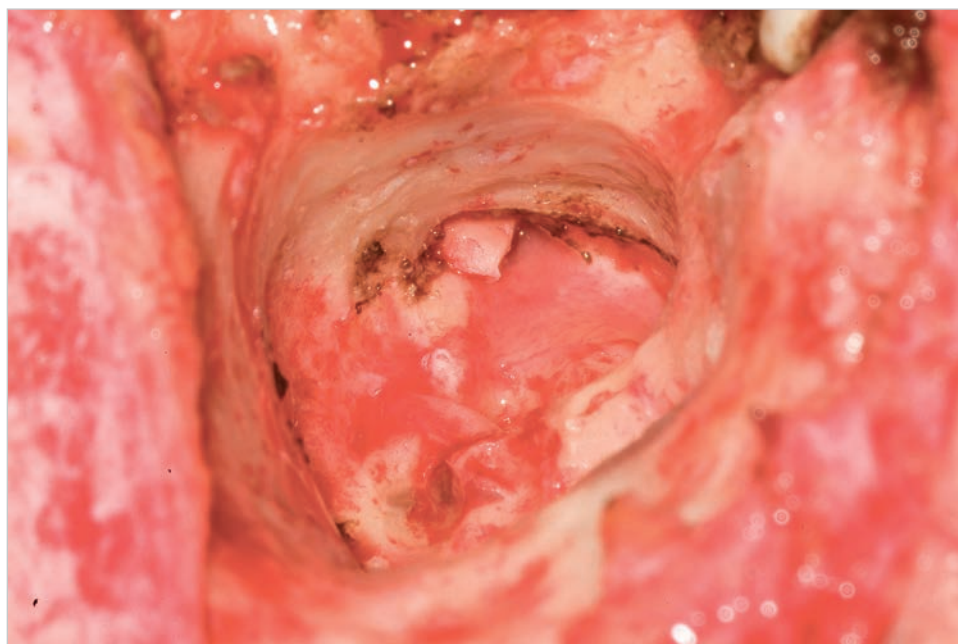


Fig. 11.27 Considering the patient's old age and the wish to make this ear trouble-free, obliteration of the cavity is indicated. As a first step of closure of the eustachian tube, a piece of cartilage is pushed into the tube.

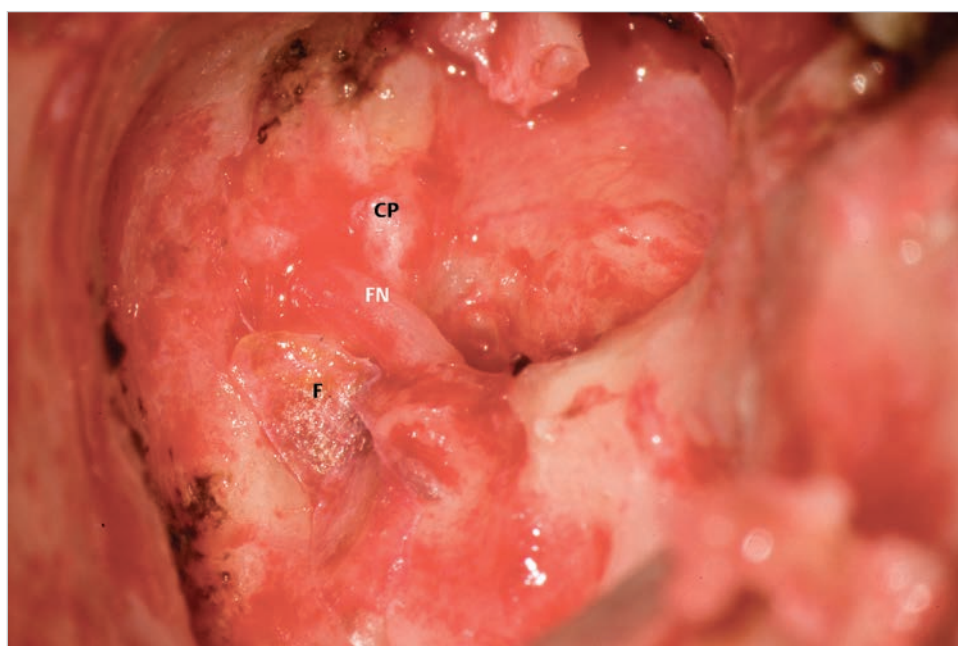


Fig. 11.28 The area of fistulae is covered with a piece of temporalis fascia. CP, cochleariform process; F, temporalis fascia; FN, facial nerve.

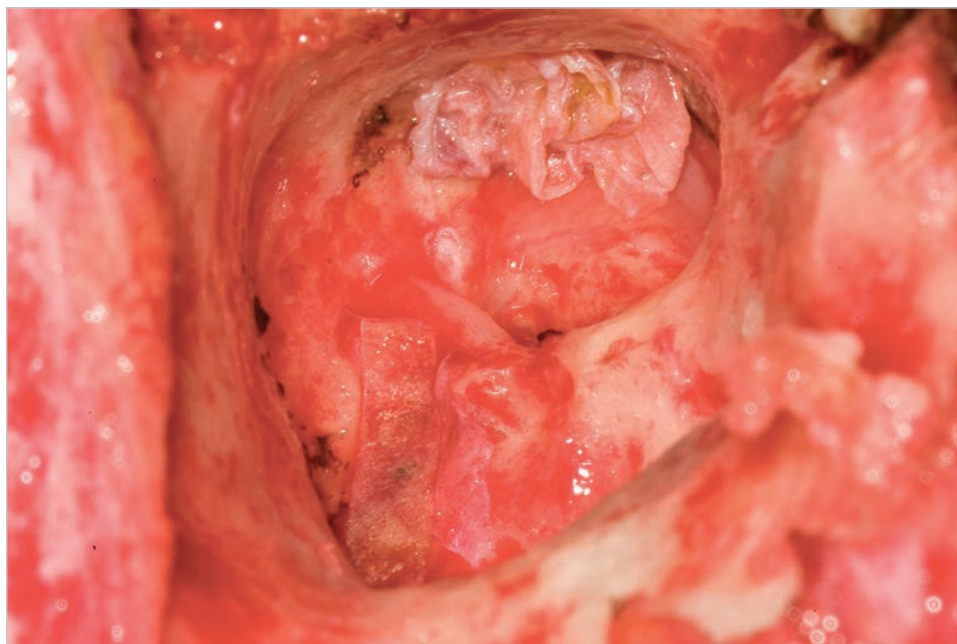


Fig. 11.29 The fistula is further covered with the other piece of fascia. Perichondrium is used to further close the eustachian tube, and the cavity is packed with abdominal fat.

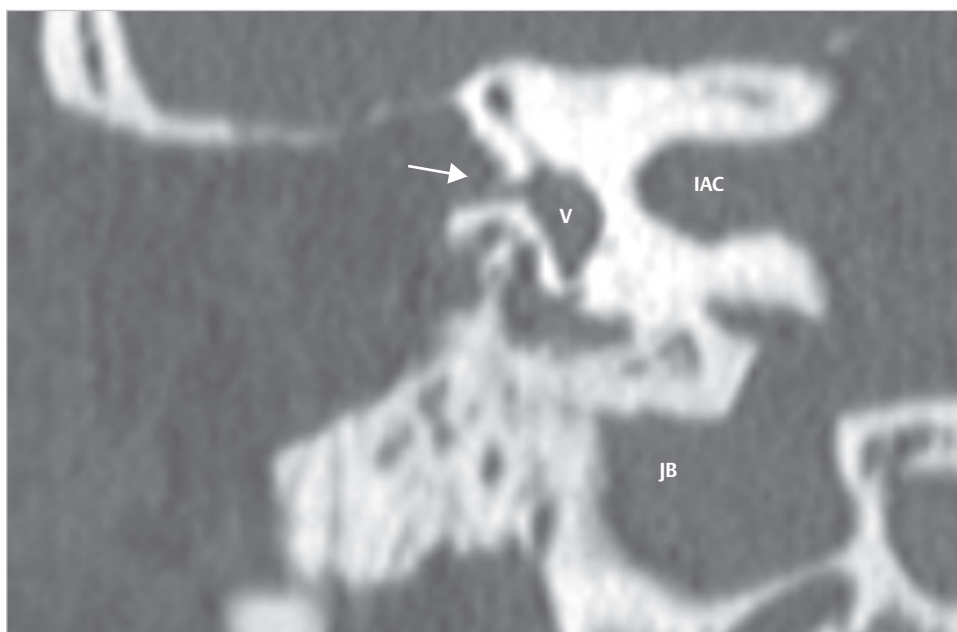


Fig. 11.30 The coronal section of postoperative CT shows that the middle fossa plate is sufficiently thinned. The cavity is filled with abdominal fat. A large fistula is identified in the lateral semicircular canal (*arrow*). IAC, internal auditory canal; JB, jugular bulb; V, vestibule.

Case 11.3 (Right Ear)

See ► Fig. 11.31, ► Fig. 11.32, ► Fig. 11.33, ► Fig. 11.34, ► Fig. 11.35, ► Fig. 11.36, ► Fig. 11.37, ► Fig. 11.38, ► Fig. 11.39, ► Fig. 11.40, ► Fig. 11.41, ► Fig. 11.42.

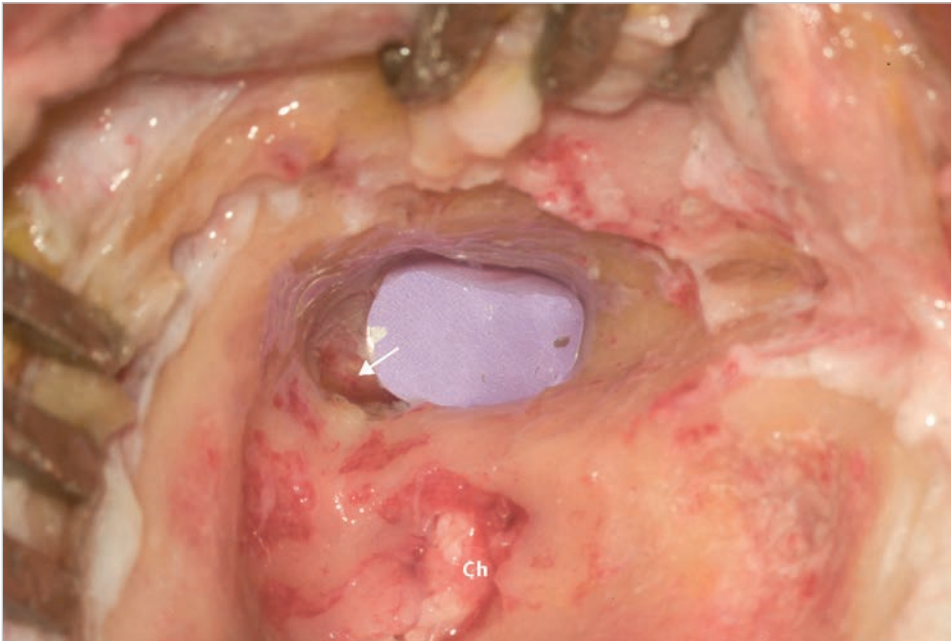


Fig. 11.31 A case of acquired cholesteatoma with severe erosion of the labyrinth. Canal wall down mastoidectomy is carried out to expose cholesteatoma entering the middle ear from the pars flaccida (*arrow*) and filling the attic and the antrum. The tympanomeatal flap is protected by an aluminum sheeting. Ch, cholesteatoma.



Fig. 11.32 The tympanic cavity is entered by reflecting the tympanomeatal flap anteriorly and holding it with an aluminum sheeting. The inferior pole of cholesteatoma only reaches the level of the facial nerve, and obliteration of the cavity is not decided at this moment.

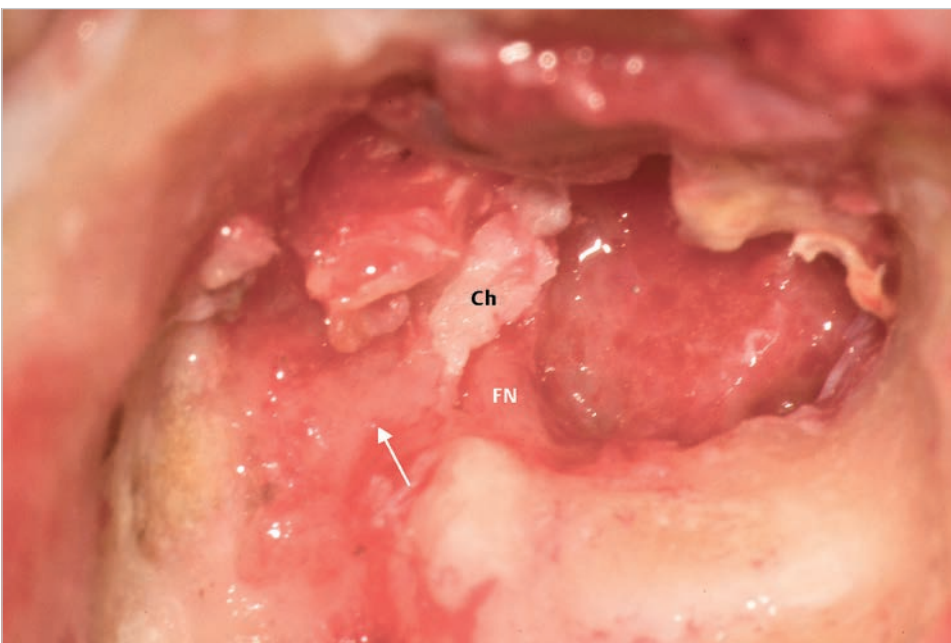


Fig. 11.33 The cholesteatoma filling the attic is partially removed to uncover newly formed bone (*arrow*) over the cholesteatoma infiltrating the medial wall. The bone should be removed with great care, since the uncovered facial nerve is in vicinity. Ch, cholesteatoma; FN, facial nerve.

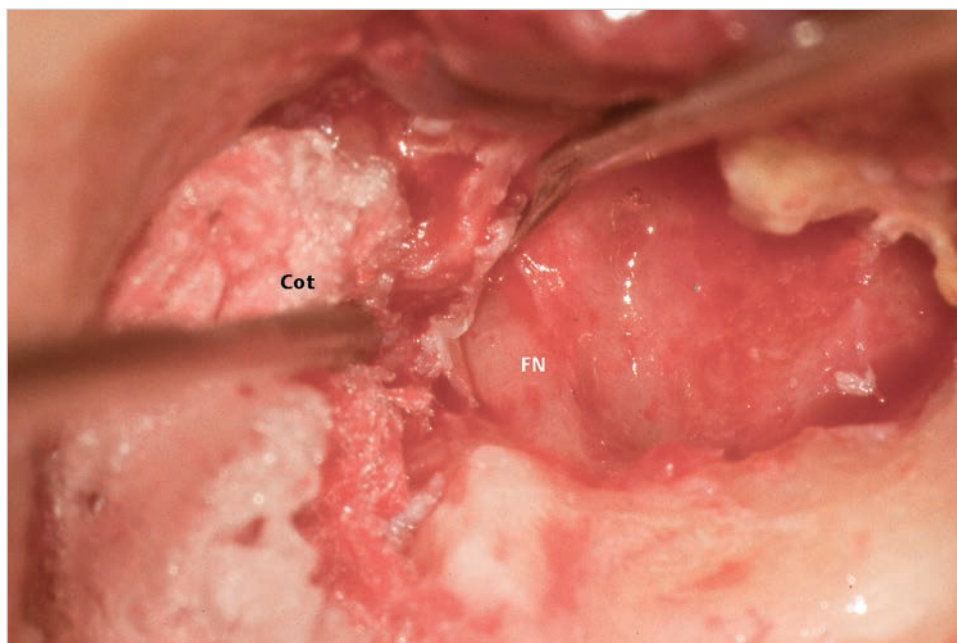


Fig. 11.34 The newly formed bone is removed with a curette, and dissection of the matrix is carried out from posterior to anterior, along the exposed facial nerve. Cottonoid is applied to control bleeding. Note that the tympanic segment of the facial nerve is exposed extensively. Cot, cottonoid; FN, facial nerve.

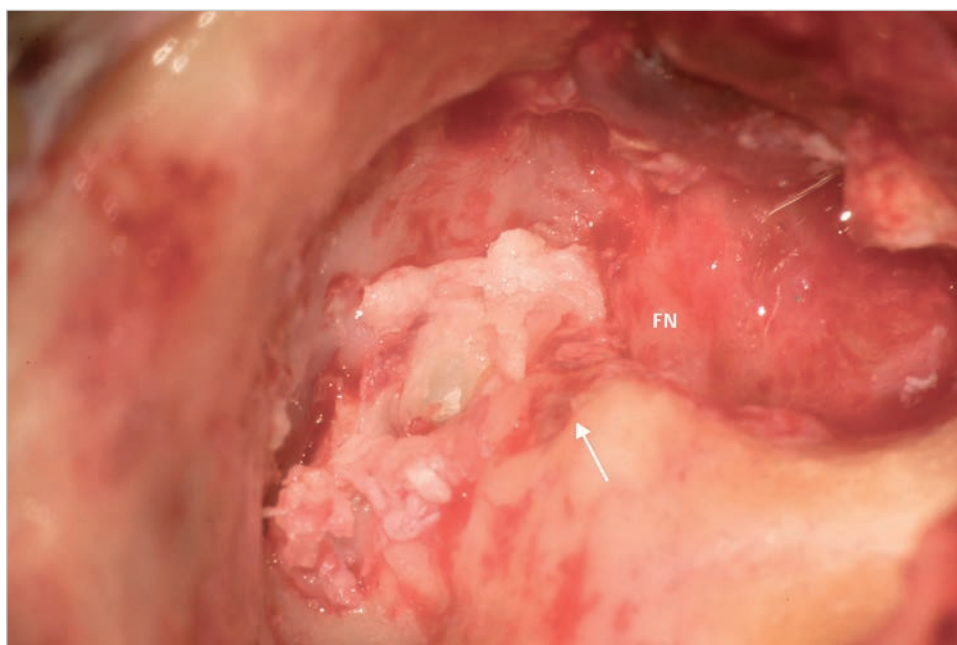


Fig. 11.35 A large labyrinthine fistula is identified in the lateral semicircular canal (*arrow*). The cholesteatoma infiltrates the cells in the medial wall of the attic, and goes medially to the facial nerve. FN, facial nerve.

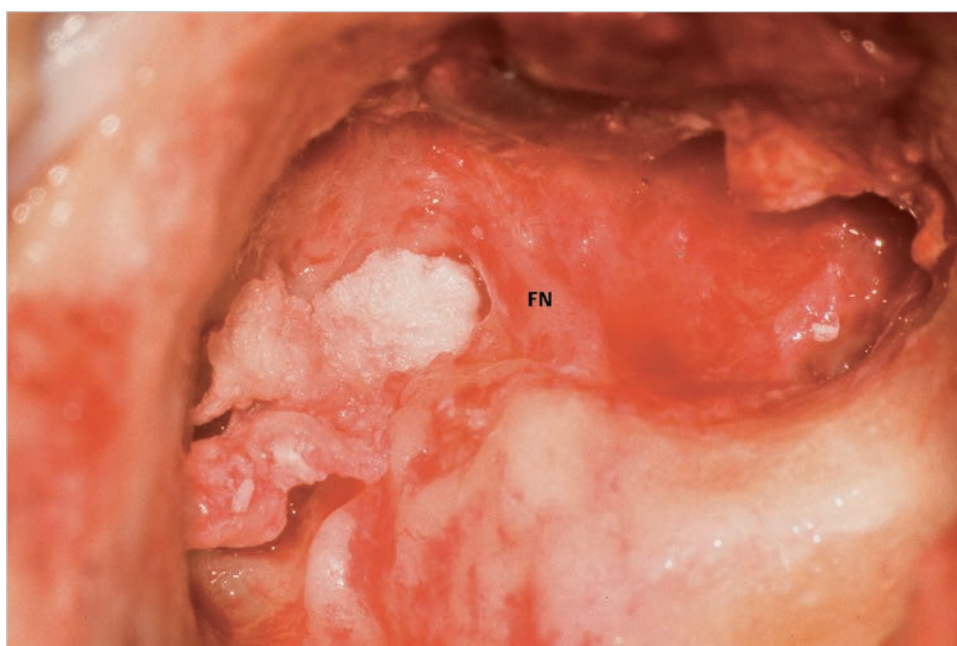


Fig. 11.36 The cholesteatoma infiltrating the medial wall of the attic is dissected from the medial face of the facial nerve. FN, facial nerve.

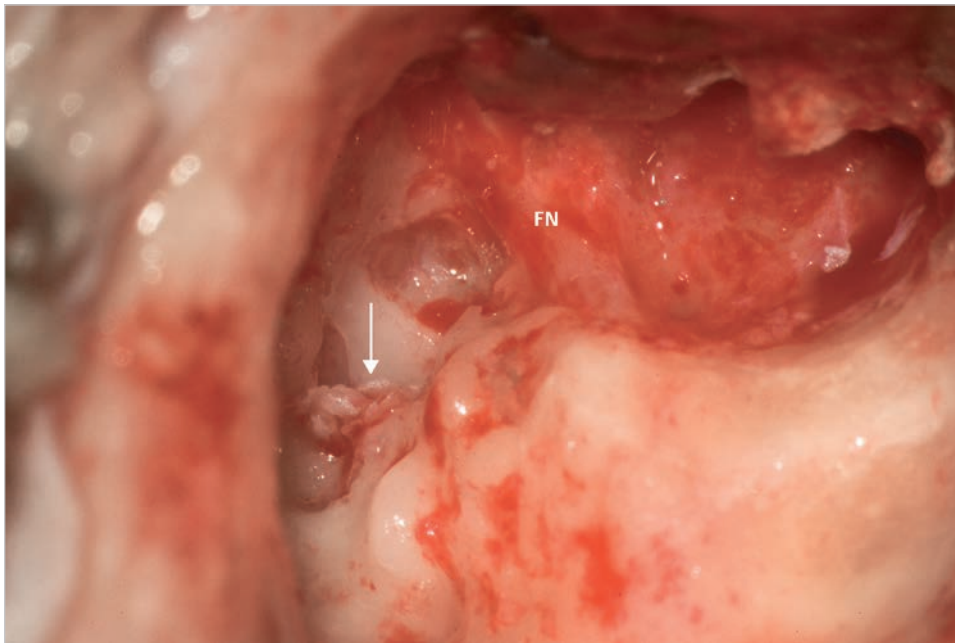


Fig. 11.37 The cholesteatoma is dissected from the facial nerve, but still remains in the cells located posteriorly (*arrow*). A small part of cholesteatoma going posteriorly toward the superior semicircular canal is indicated by an arrow. FN, facial nerve.

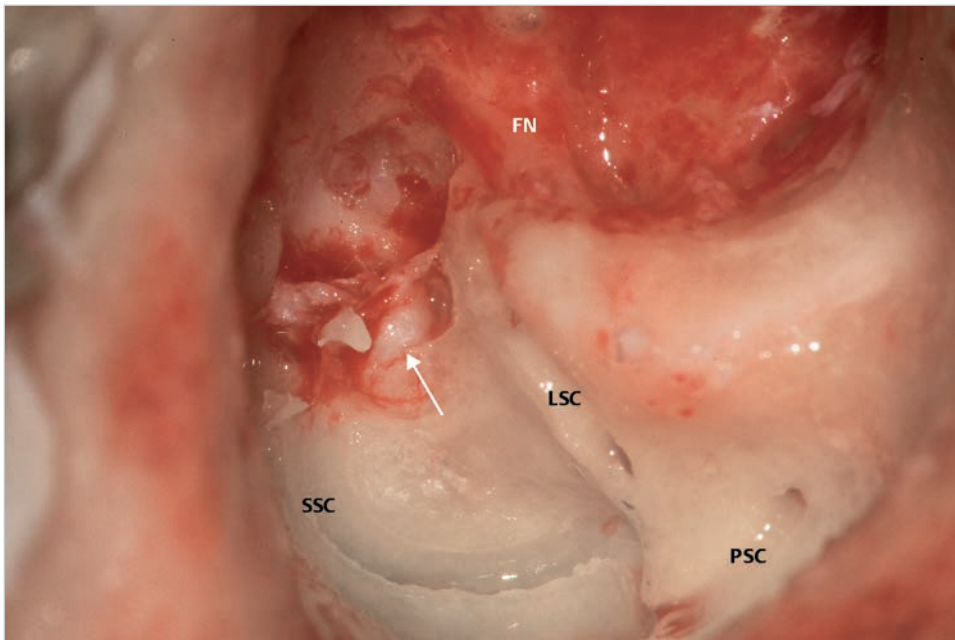


Fig. 11.38 Since the cholesteatoma erodes the superior semicircular canal and invaginates into the ampulla of the superior semicircular canal (*arrow*), labyrinthectomy is carried out. Three semicircular canals opened are seen. FN, facial nerve; LSC, lateral semicircular canal; PSC, posterior semicircular canal; SSC, superior semicircular canal.

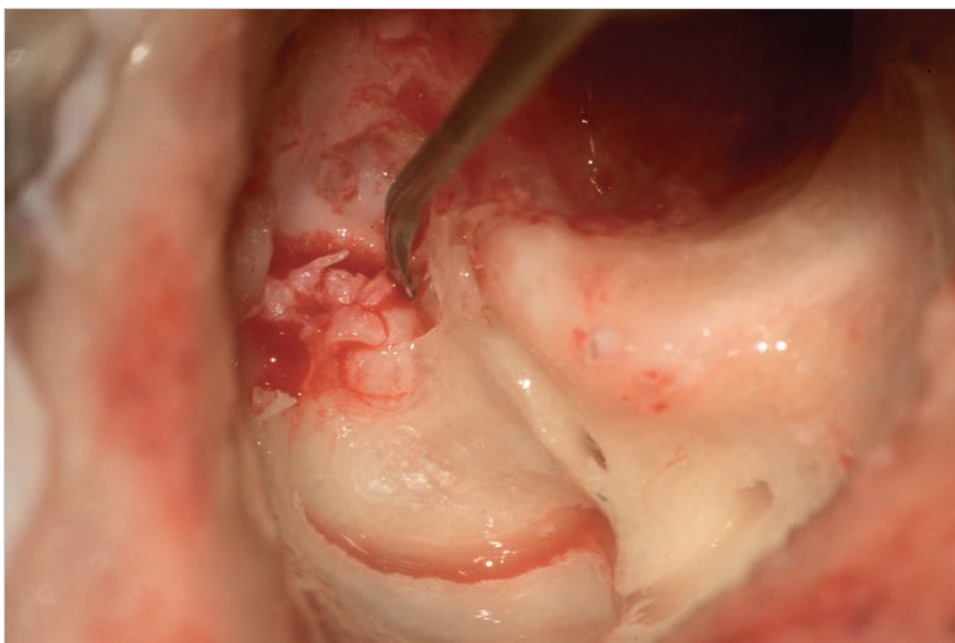


Fig. 11.39 The cholesteatoma is dissected from the ampulla of the superior semicircular canal.

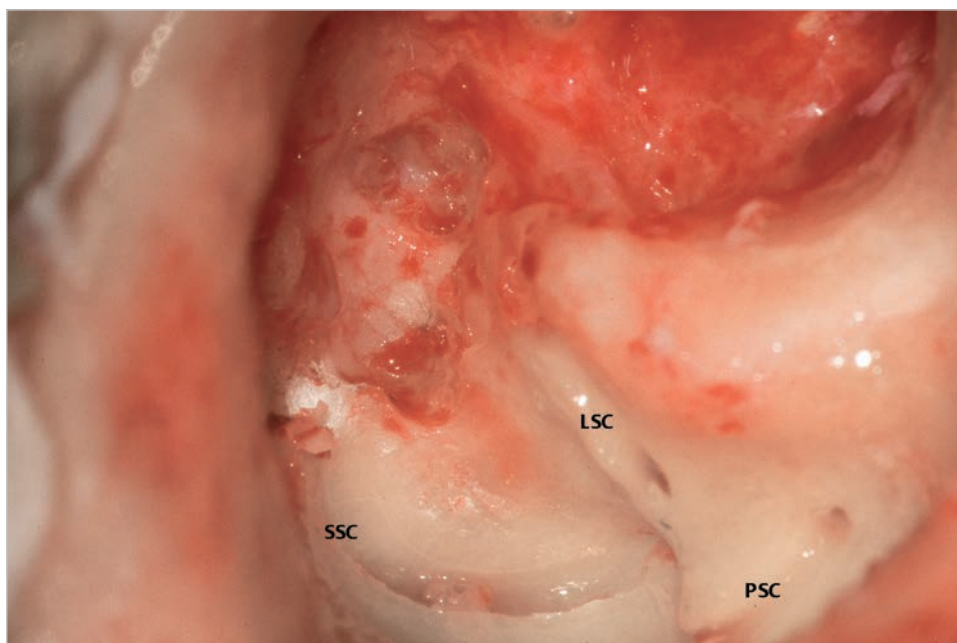


Fig. 11.40 The cholesteatoma is eradicated from the middle ear. LSC, lateral semicircular canal; PSC, posterior semicircular canal; SSC, superior semicircular canal.

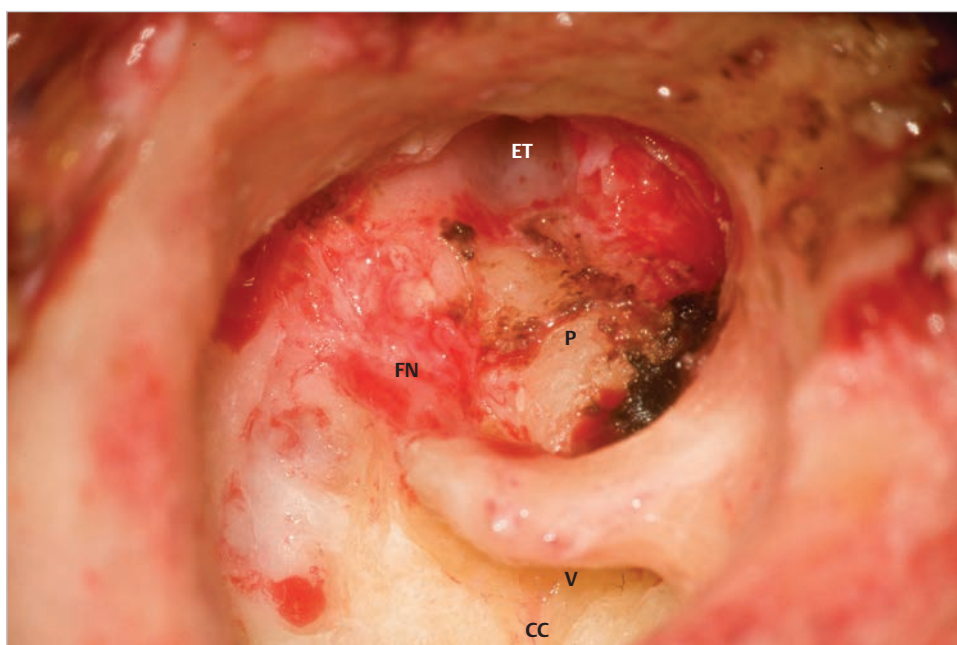


Fig. 11.41 All the semicircular canals are drilled, and the vestibule is opened to remove saccule and utricle. Closure of the eustachian tube and obliteration of the cavity with abdominal fat follow. CC, common crus; ET, eustachian tube; FN, facial nerve; P, promontory; V, vestibule.

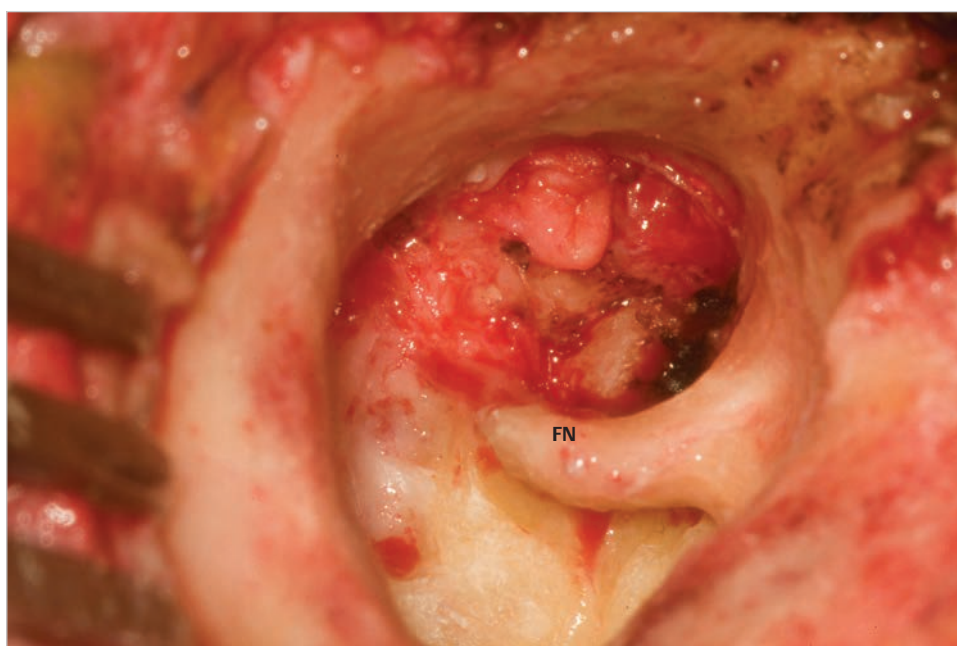


Fig. 11.42 The eustachian tube is closed with pieces of cartilage and periosteum. Packing of the cavity with abdominal fat follows. FN, facial nerve.

Case 11.4 (Right Ear)

See ► Fig. 11.43, ► Fig. 11.44, ► Fig. 11.45, ► Fig. 11.46, ► Fig. 11.47, ► Fig. 11.48, ► Fig. 11.49, ► Fig. 11.50, ► Fig. 11.51, ► Fig. 11.52, ► Fig. 11.53, ► Fig. 11.54, ► Fig. 11.55.

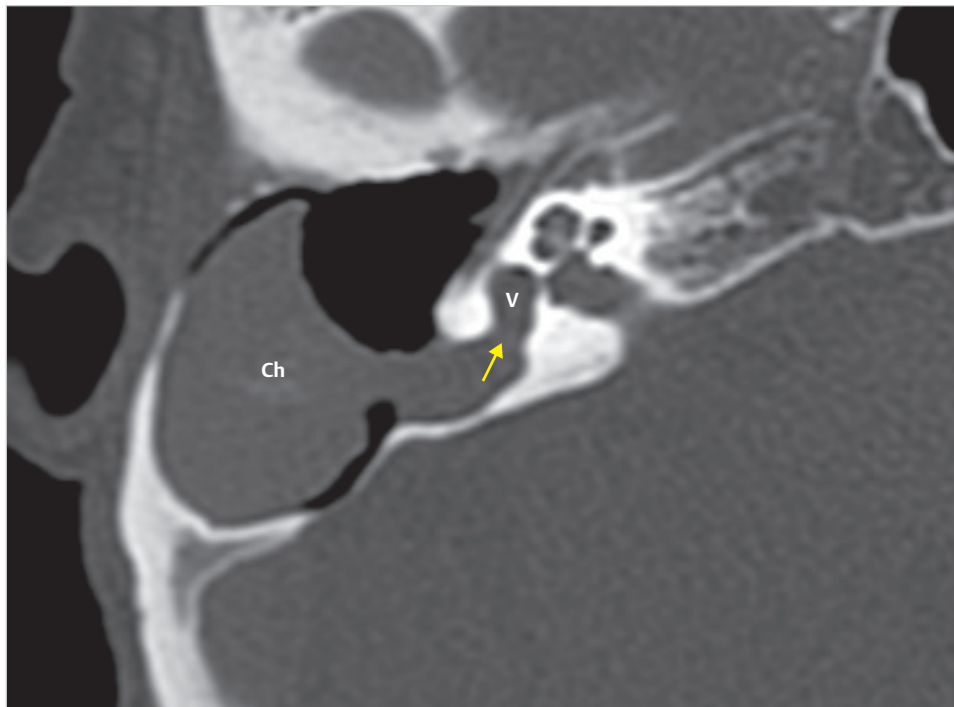


Fig. 11.43 The patient underwent middle ear surgery in childhood. Immediate hearing loss followed the surgery, and the patient has never been followed up for tens of years. Hearing examination revealed unmeasurable bone conduction. The preoperative CT shows formation of huge cholesteatoma eroding not only semicircular canals but also the vestibule (*arrow*). Ch, cholesteatoma; V, vestibule.

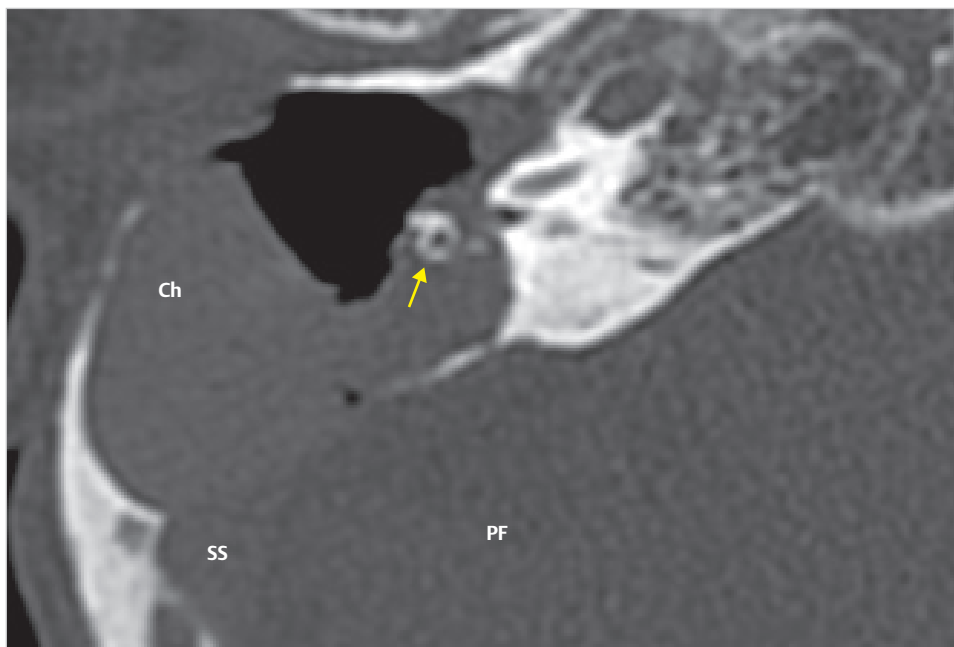


Fig. 11.44 The more caudal section shows extensive exposure of the posterior fossa dura and the sigmoid sinus. The facial nerve (*arrow*) is completely surrounded by cholesteatoma at this level. Ch, cholesteatoma; PF, posterior fossa; SS, sigmoid sinus.

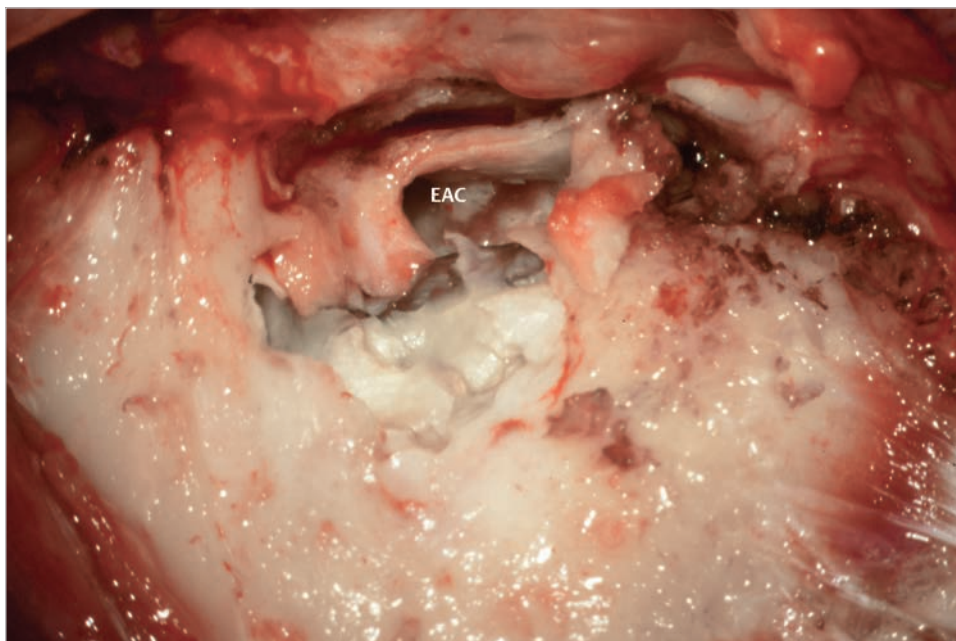


Fig. 11.45 Surface of the mastoid is exposed through retroauricular incision. Cholesteatoma filled with debris eroding surface of the mastoid is seen. EAC, external auditory canal.

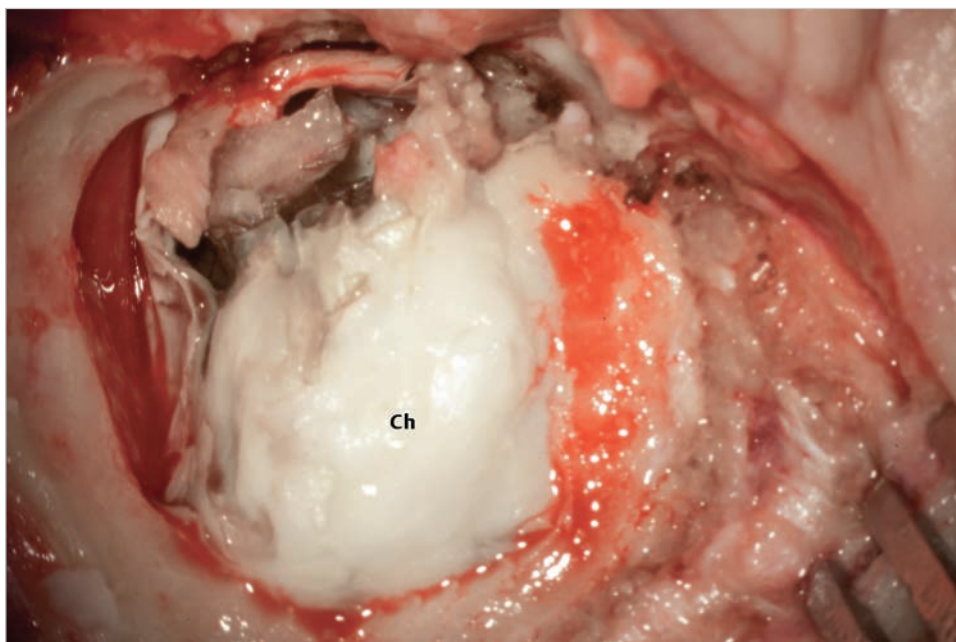


Fig. 11.46 Cholesteatoma occupying the very large defect in the mastoid is shown. Ch, cholesteatoma.

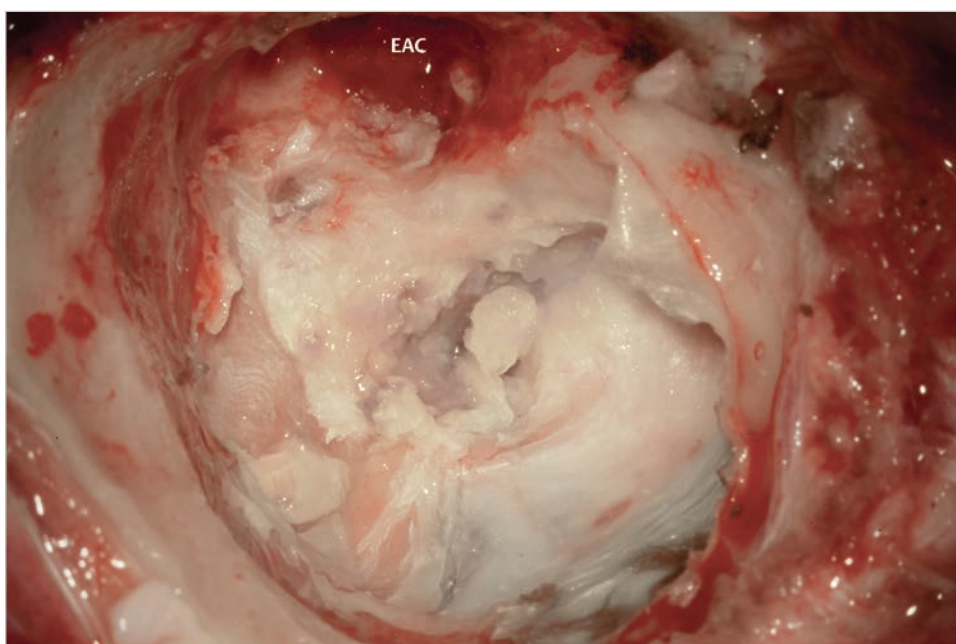


Fig. 11.47 The majority of debris is evacuated and matrix covering the cavity is visualized. EAC, external auditory canal.

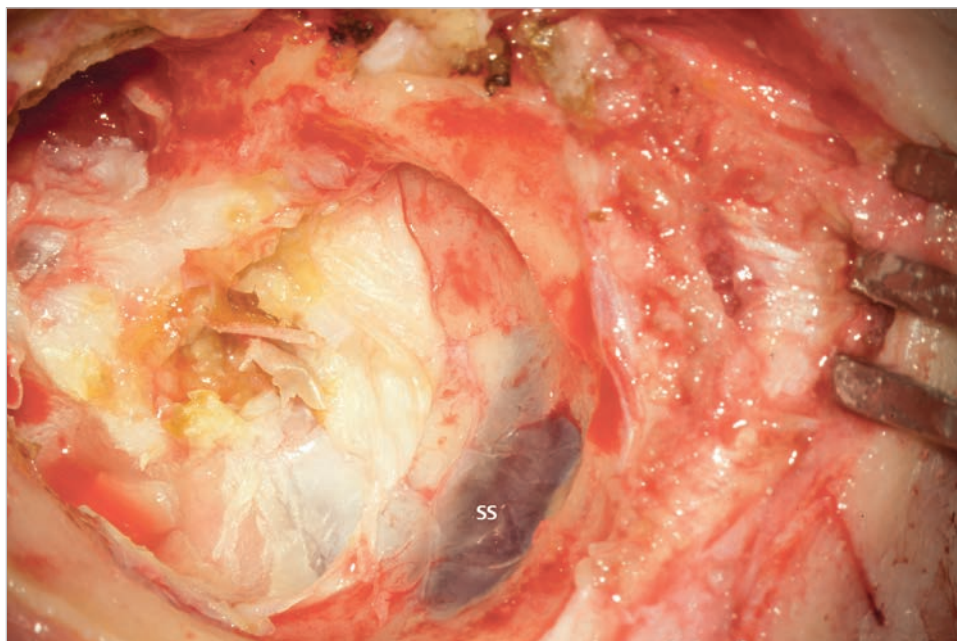


Fig. 11.48 The matrix is dissected from the posterior wall of the cavity. The sigmoid sinus extensively exposed is visualized. SS, sigmoid sinus.

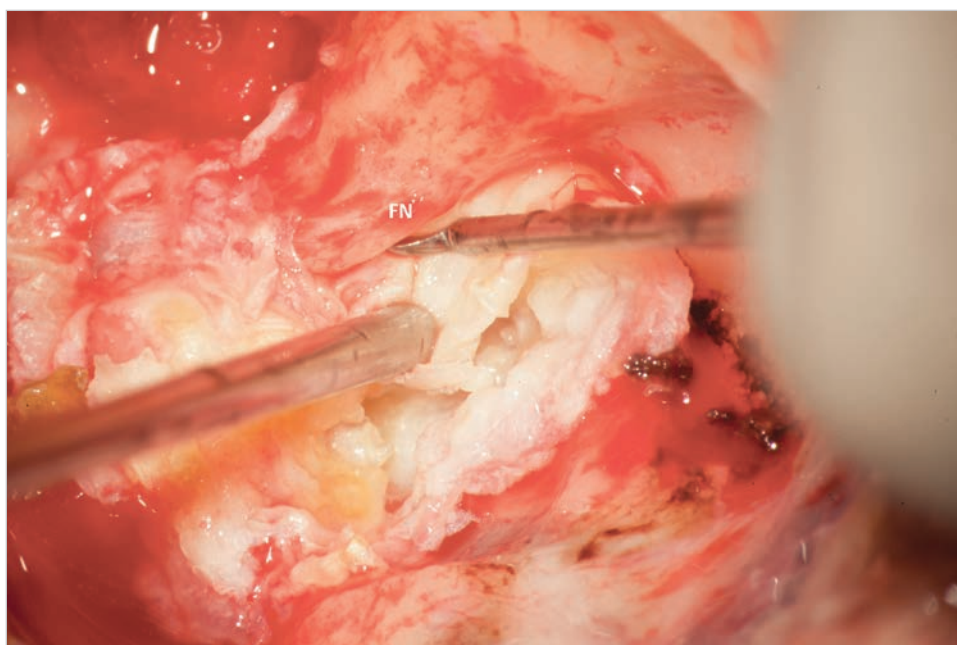


Fig. 11.49 The cholesteatoma is dissected from the area medially to the facial nerve (FN).

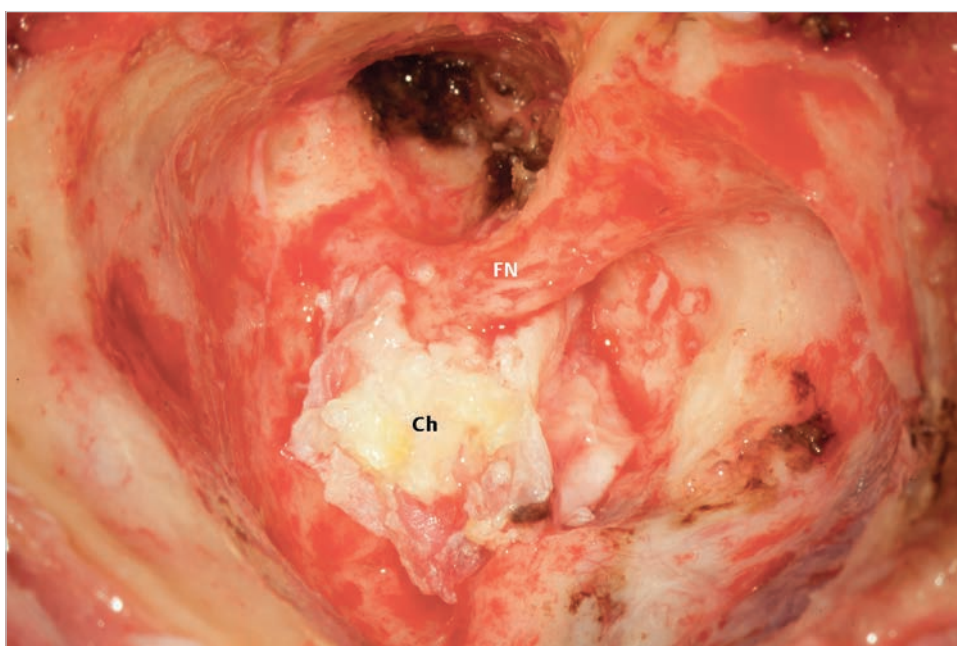


Fig. 11.50 The cholesteatoma infiltrating the labyrinth is shown. Ch, cholesteatoma; FN, facial nerve.

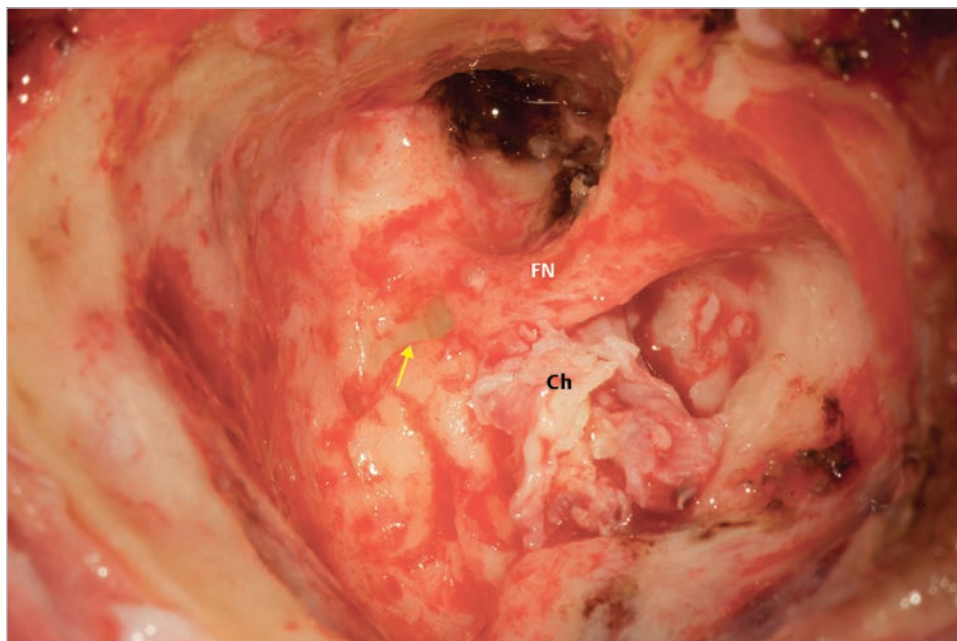


Fig. 11.51 Removal of cholesteatoma opened the superior semicircular canal (*arrow*). The lateral semicircular canal is completely eroded. Ch, cholesteatoma; FN, facial nerve.

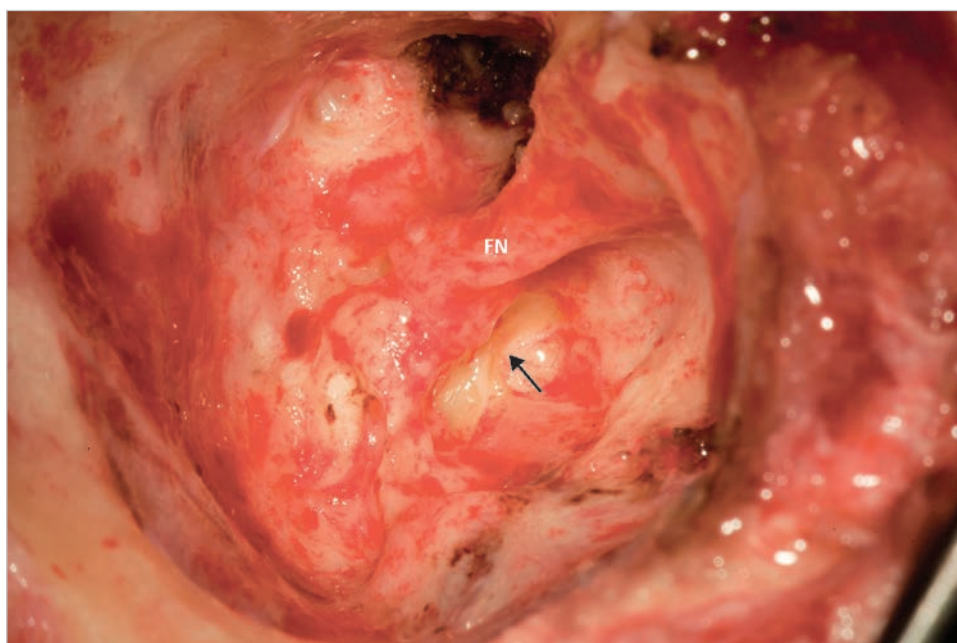


Fig. 11.52 Removal of cholesteatoma from the posterior face of the vestibule is accomplished. An opening of the vestibule can be seen (*arrow*). FN, facial nerve.



Fig. 11.53 The vestibule and remnants of semicircular canals are opened to ensure total removal of cholesteatoma infiltrating the inner ear. FN, facial nerve; V, vestibule.

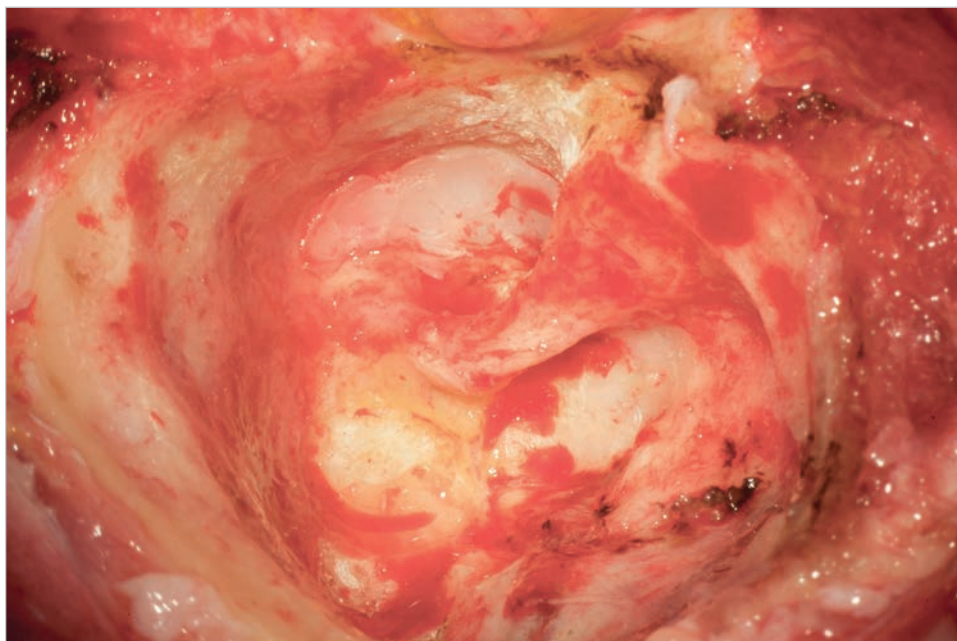


Fig. 11.54 The eustachian tube is closed with pieces of periosteum and bone wax, and the cavity is closed with abdominal fat.

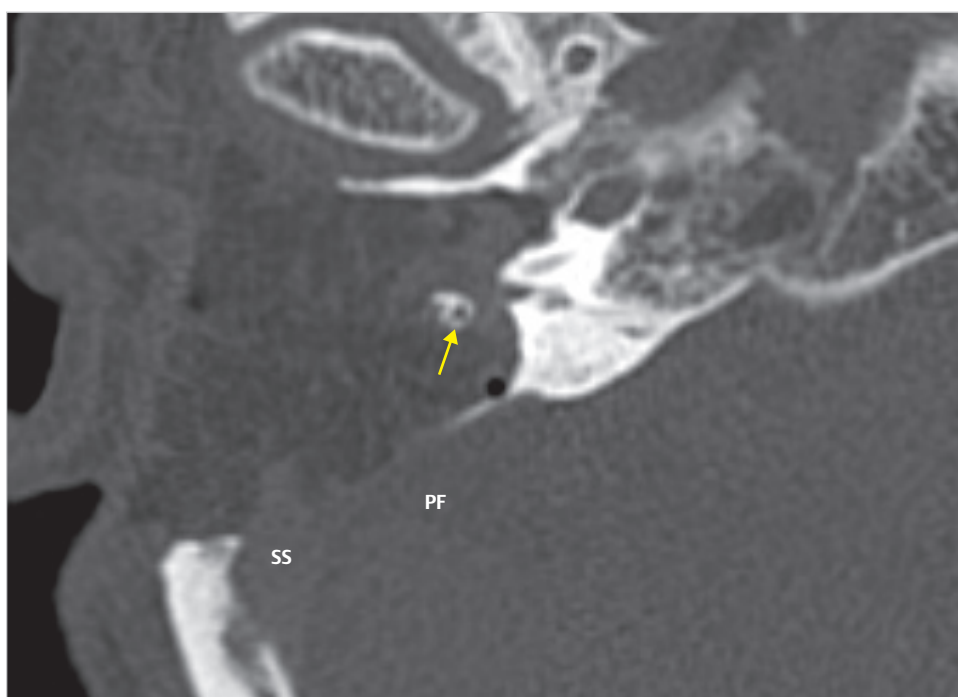


Fig. 11.55 The postoperative CT shows sufficient removal of bone from the temporal bone. The arrow indicates the fallopian canal. PF, posterior fossa; SS, sigmoid sinus.

Case 11.5 (Right Ear)

See ▶ Fig. 11.56, ▶ Fig. 11.57, ▶ Fig. 11.58, ▶ Fig. 11.59, ▶ Fig. 11.60, ▶ Fig. 11.61, ▶ Fig. 11.62, ▶ Fig. 11.63, ▶ Fig. 11.64, ▶ Fig. 11.65, ▶ Fig. 11.66, ▶ Fig. 11.67.

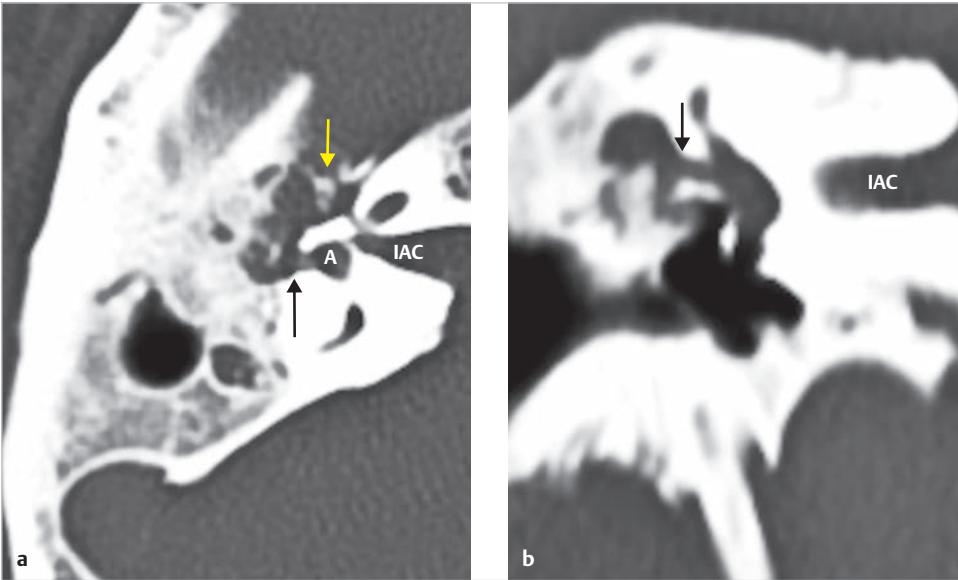


Fig. 11.56 A case of residual cholesteatoma in canal wall down cavity is shown. Hearing of this ear is unusable. Both the axial (a) and coronal (b) images show presence of very large fistula in the lateral semicircular canal (black arrows). New bone formation covering the geniculate ganglion can be identified (yellow arrow). A, ampulla of lateral semicircular canal; IAC, internal auditory canal.

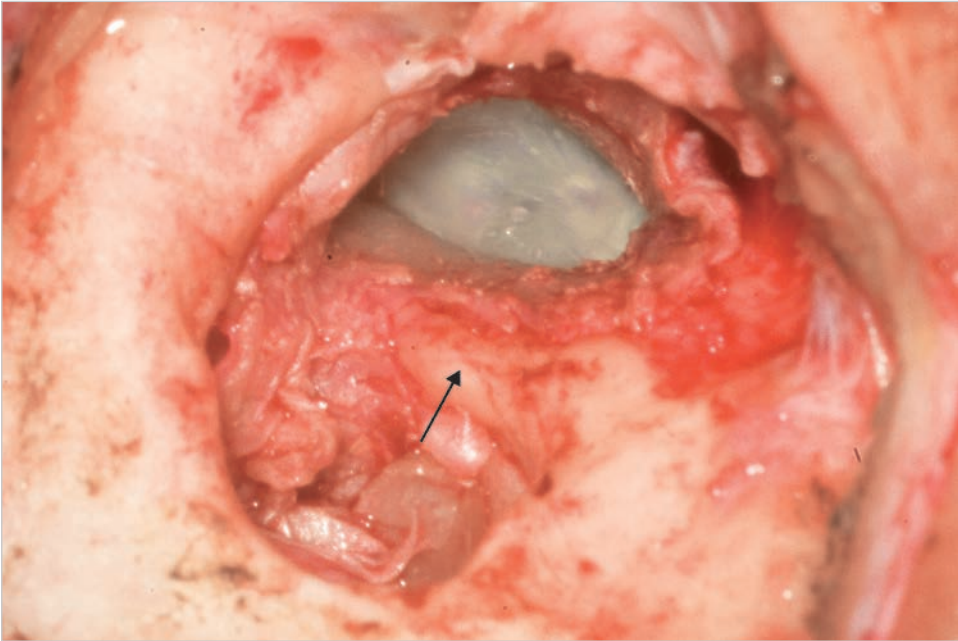


Fig. 11.57 The cavity is opened through retroauricular incision. No inflammation is seen in the cavity. The facial ridge remains very high (arrow).

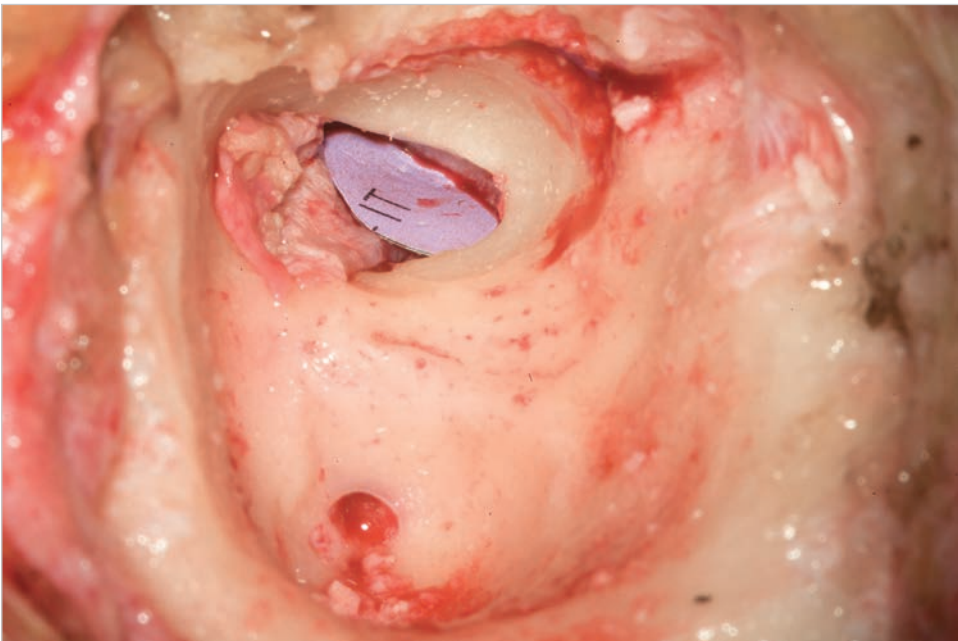


Fig. 11.58 Drilling of the mastoid includes lowering mastoid and removal of cavity edges to obtain round-shaped saucerized cavity.

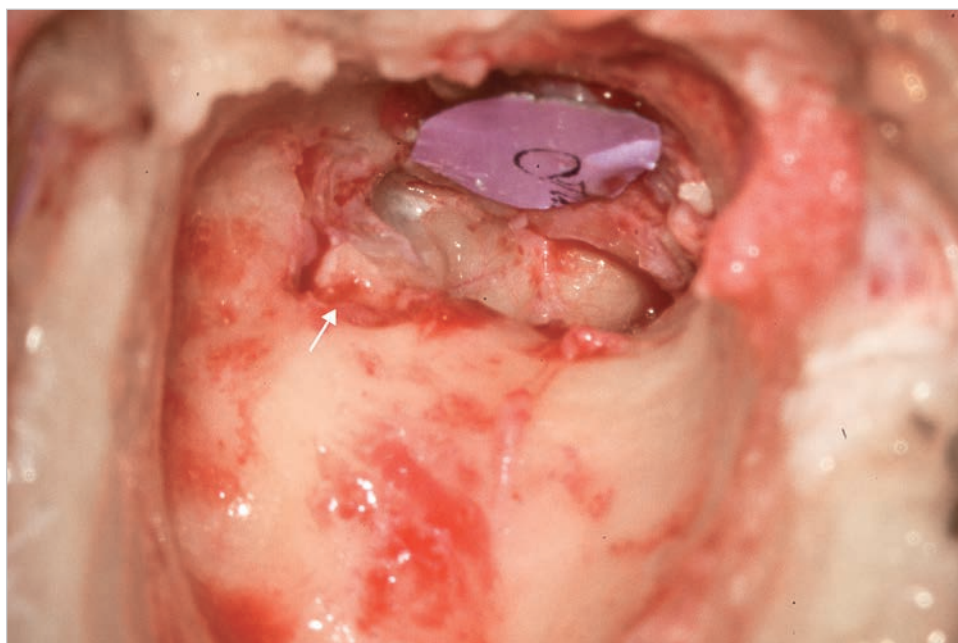


Fig. 11.59 The arrow indicates cholesteatoma infiltrating the space under the thick bone forming the lateral wall of the attic.

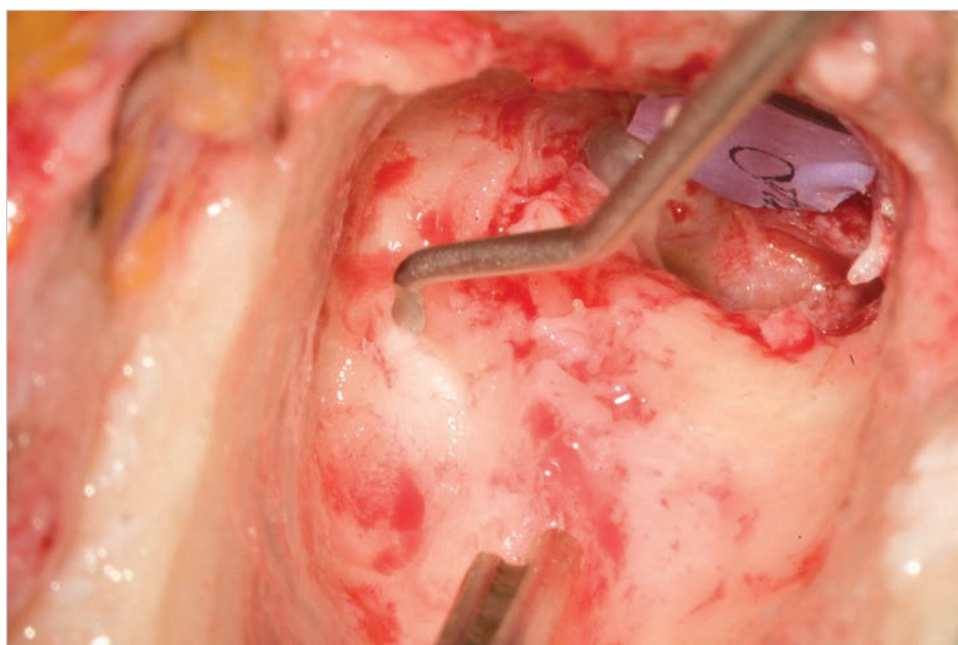


Fig. 11.60 The thick new bone covering the medial wall of the attic is drilled taking care not to damage the facial nerve. The instrument points the whitish area where cholesteatoma is started to be seen through the bone.

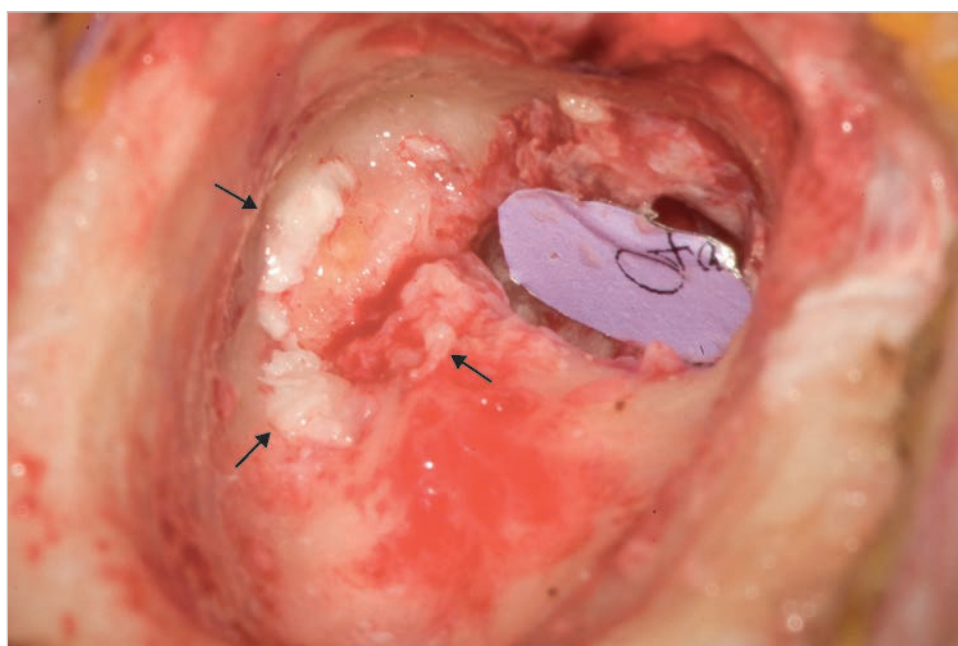


Fig. 11.61 The bony coverage is partially removed. Note the thickness of the bone covering the cholesteatoma (arrows). The case indicates necessity of removal of newly formed bone in cholesteatoma surgery.



Fig. 11.62 The newly formed bone is removed, and the cholesteatoma is visualized. CP, cochleariform process; FN, facial nerve.

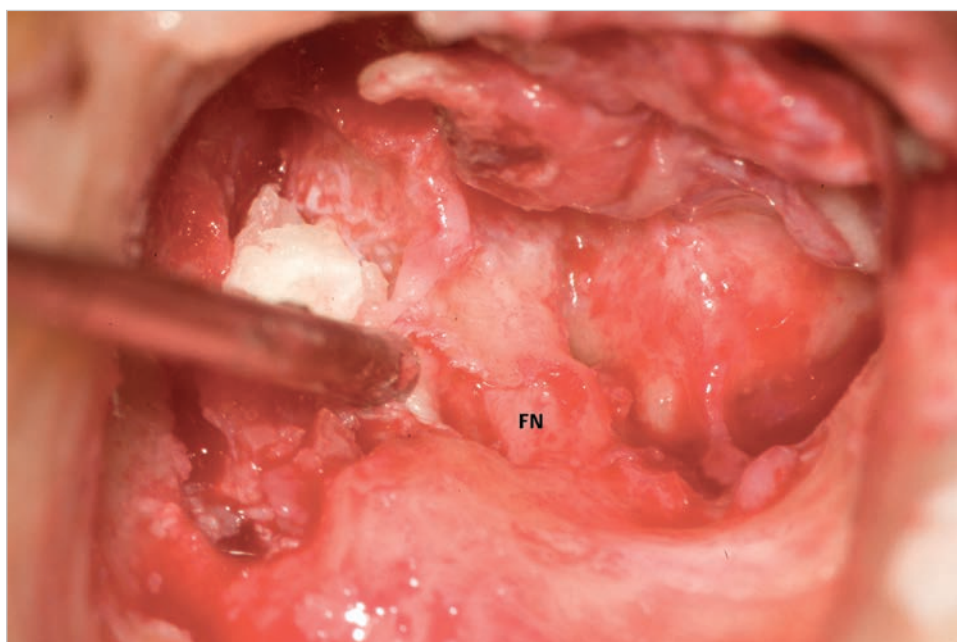


Fig. 11.63 The matrix of the cholesteatoma is dissected from the superior face of the facial nerve. Exposed facial nerve is seen. The nerve is still covered with newly formed bone anteriorly. FN, facial nerve.

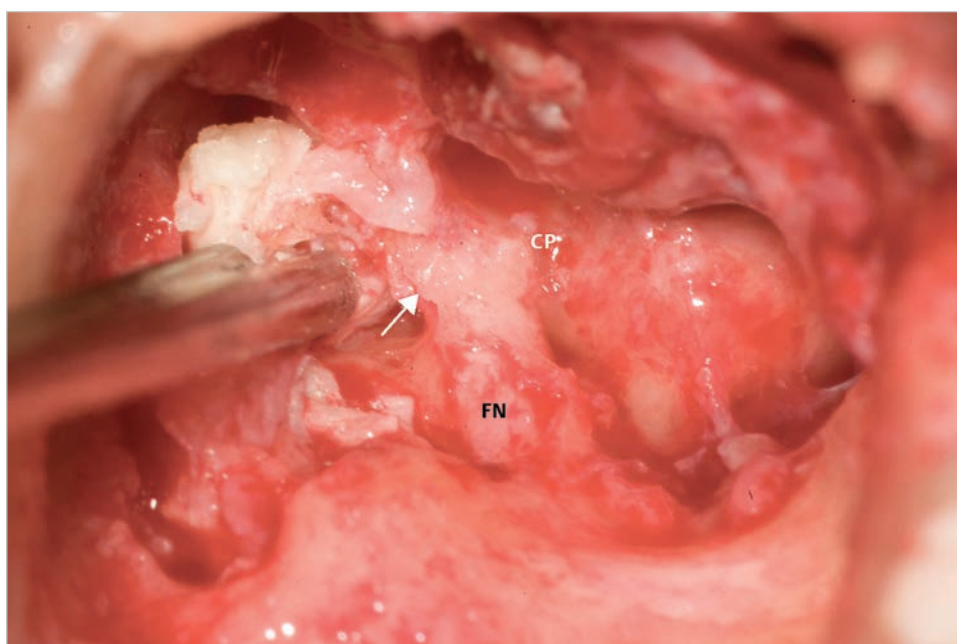


Fig. 11.64 The cholesteatoma infiltrating medially to the tympanic segment of the facial nerve is dissected. To ensure complete removal of the matrix, the thin plate of newly formed bone (*arrow*) over the facial nerve near the cochleariform process should be removed. FN, facial nerve; CP, cochleariform process; FN, facial nerve.

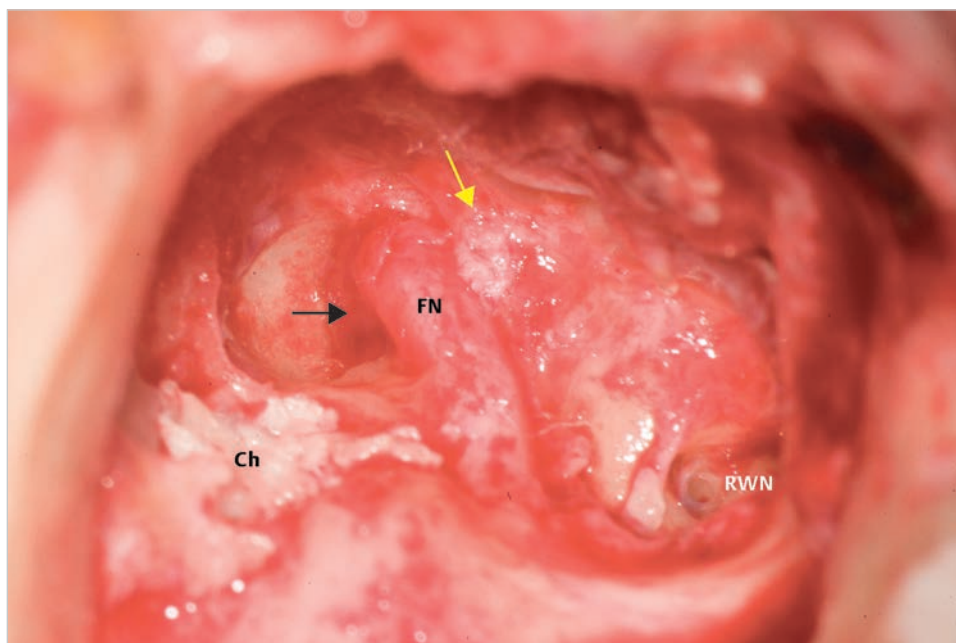


Fig. 11.65 The newly formed bone covering the attic is removed completely, and the cholesteatoma is dissected from the tympanic segment of the facial nerve. The labyrinthine segment of the facial nerve exposed by the cholesteatoma is seen (*black arrow*). Perilabyrinthine cells are still infiltrated by cholesteatoma. The eustachian tube is closed with periosteum (*yellow arrow*). Ch, cholesteatoma; FN, facial nerve; RWN, round window niche.

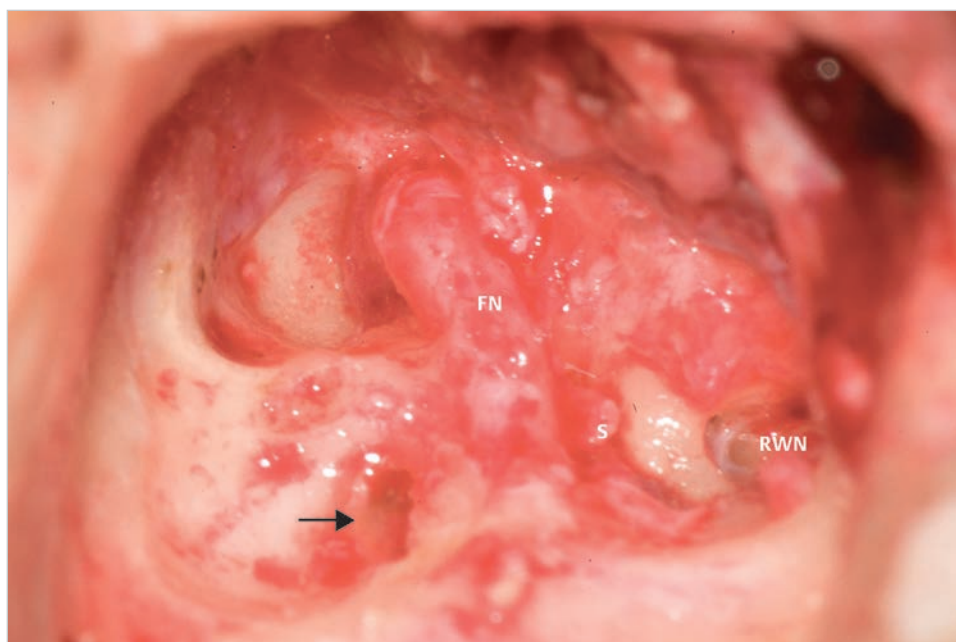


Fig. 11.66 Dissection of cholesteatoma matrix from the posterior attic revealed a large labyrinthine fistula in the lateral semicircular canal near the ampulla (*arrow*). FN, facial nerve; RWN, round window niche; S, stapes.



Fig. 11.67 The lateral semicircular canal is opened to make sure absence of matrix. The area is closed with a piece of fascia, and the cavity is packed with abdominal fat.

Case 11.6 (Right Ear)

See ► Fig. 11.68, ► Fig. 11.69, ► Fig. 11.70, ► Fig. 11.71, ► Fig. 11.72, ► Fig. 11.73, ► Fig. 11.74, ► Fig. 11.75, ► Fig. 11.76, ► Fig. 11.77.



Fig. 11.68 The patient underwent canal wall down procedure for cholesteatoma elsewhere and visited our office with a dead ear. A swelling of the posterior meatal wall closes the external auditory canal.

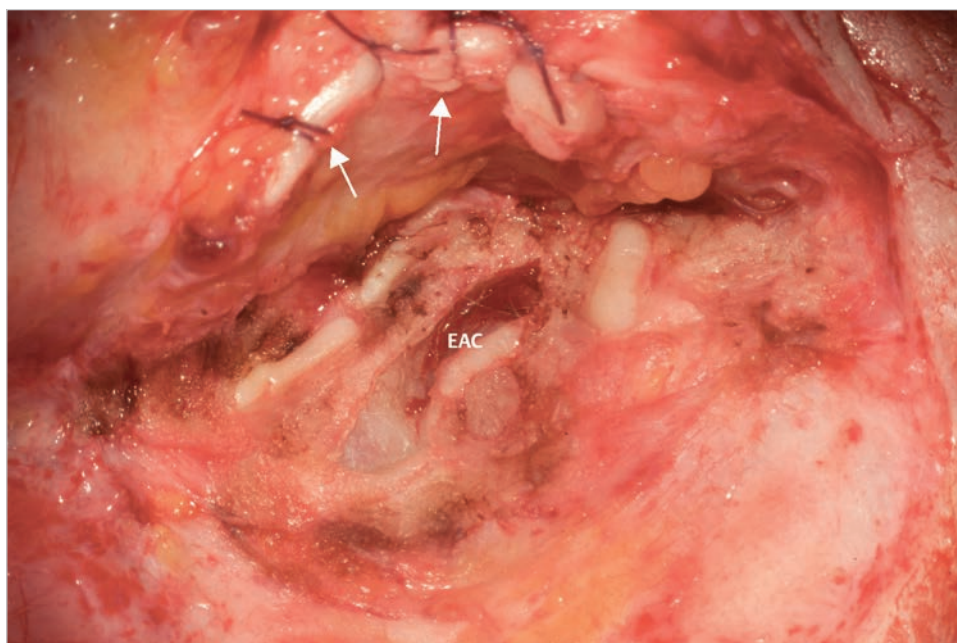


Fig. 11.69 A retroauricular incision is carried out to expose scar tissue filling the mastoid. A blind-sac closure of the external auditory canal has already been conducted (*arrows*). The external auditory canal transected at the level of the cartilaginous portion is seen. EAC, external auditory canal.

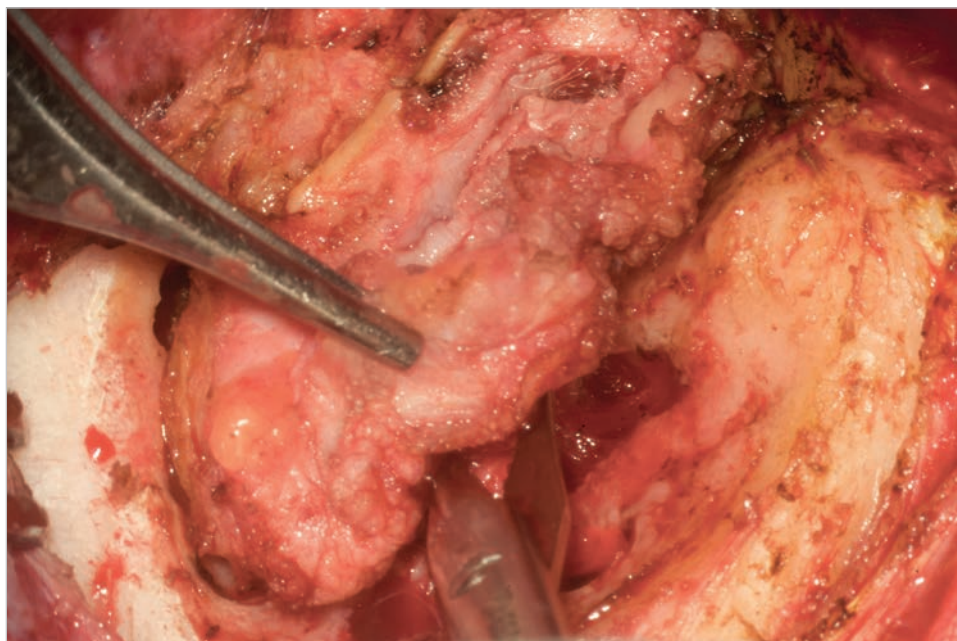


Fig. 11.70 The cavity is filled with very thick scar tissue covered with inflamed skin. The scar tissue should be reduced to visualize the cavity wall.

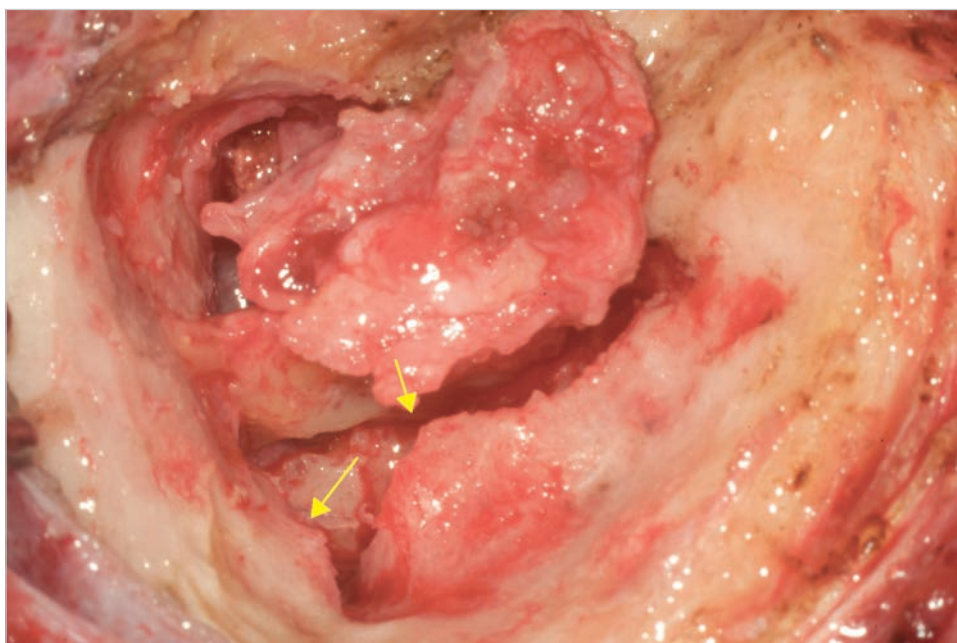


Fig. 11.71 Dissection of the scar tissue from the badly performed canal wall down cavity with sharp bony protrusions (*arrows*) is in progress.



Fig. 11.72 The cavity is rounded, and scar tissue with inflamed skin is further reduced to reach the area of the tympanic cavity. Accumulation of debris is identified at the bottom of the meatus.

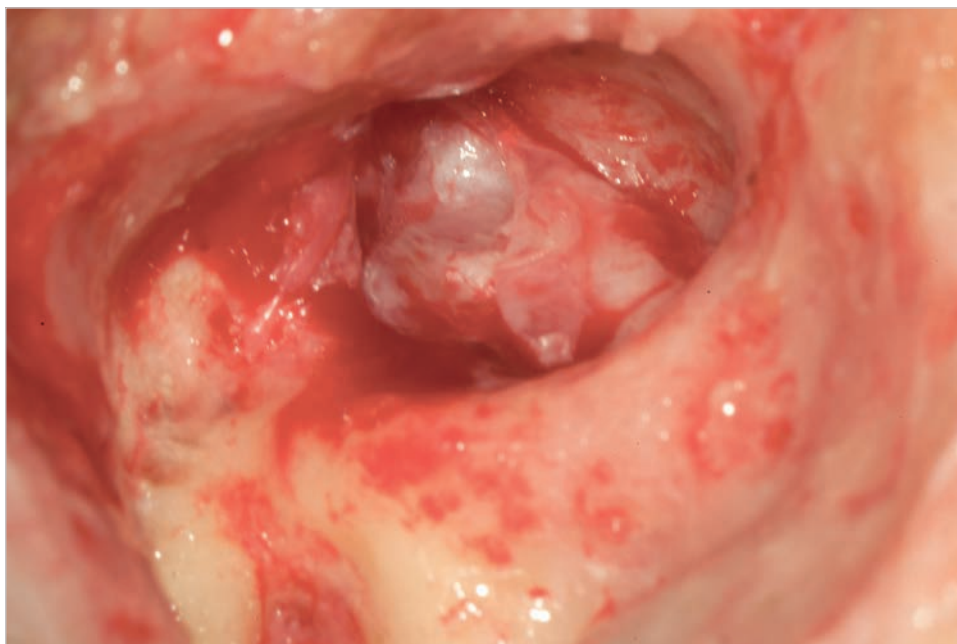


Fig. 11.73 The tympanic membrane compressed toward the medial wall is seen.

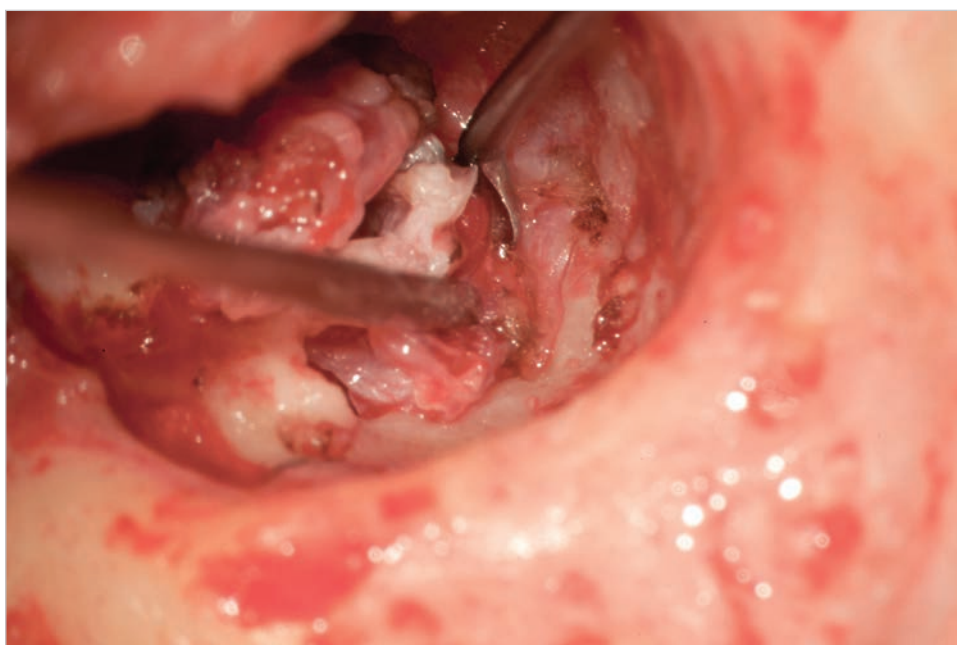


Fig. 11.74 Removal of the skin is started from the hypotympanum to avoid risking fragile structures such as the round window, the stapes, and the facial nerve.



Fig. 11.75 Removal of the skin is started from the hypotympanum to avoid risking fragile structures such as the round window, the stapes, and the facial nerve.



Fig. 11.76 The cavity is rounded to ensure complete removal of skin. The arrow indicates the cochleariform process.

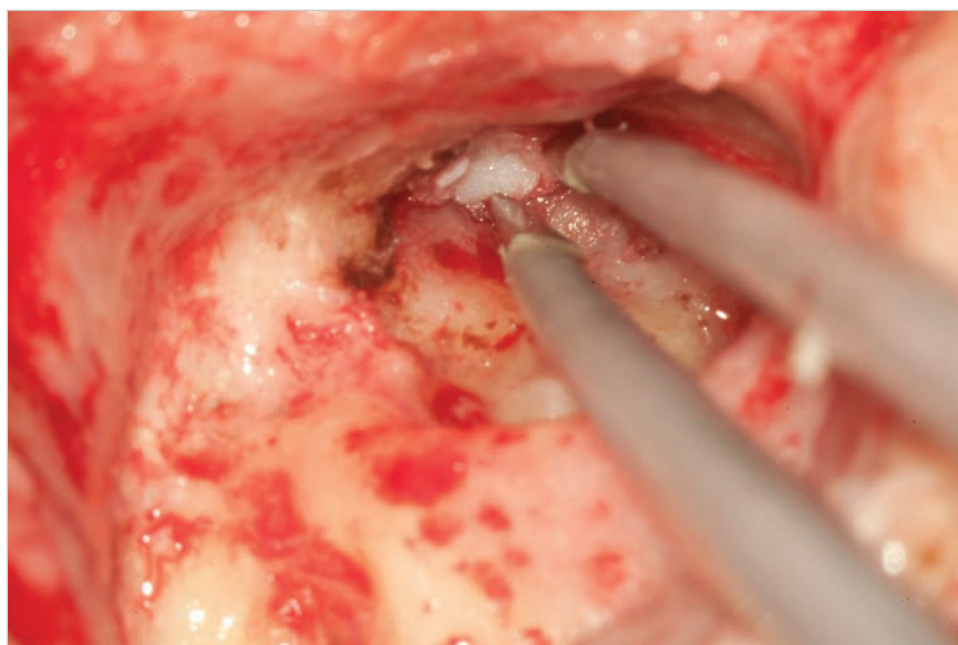


Fig. 11.77 The eustachian tube is closed with pieces of periosteum, and the cavity is packed with abdominal fat.

Case 11.7 (Left Ear)

See ► Fig. 11.78, ► Fig. 11.79, ► Fig. 11.80, ► Fig. 11.81, ► Fig. 11.82, ► Fig. 11.83, ► Fig. 11.84, ► Fig. 11.85, ► Fig. 11.86, ► Fig. 11.87, ► Fig. 11.88.

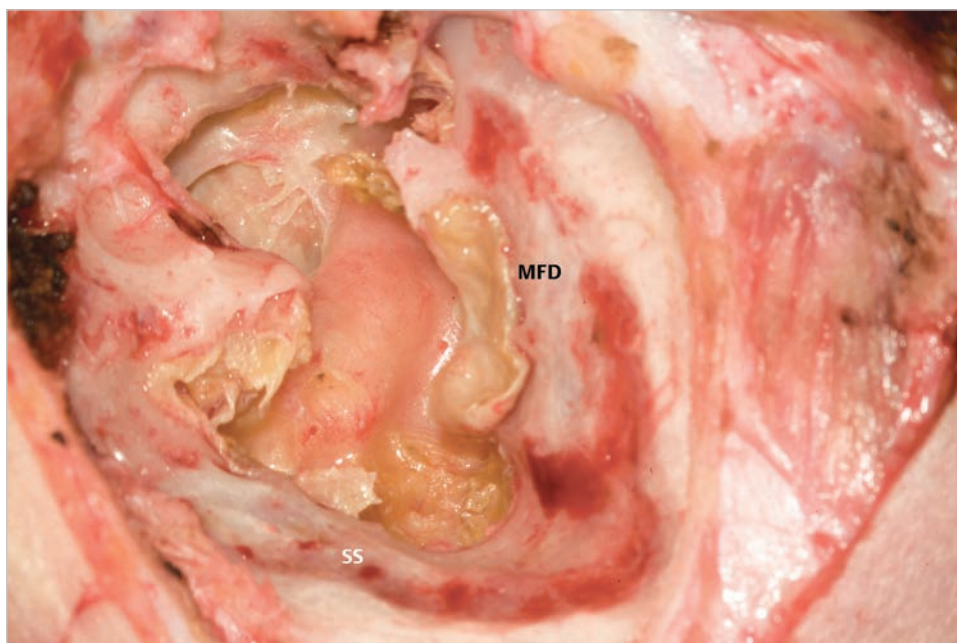


Fig. 11.78 A case of open cavity problem with intractable otorrhea after canal wall down. Sharp edges are already removed, and the middle fossa dura and the sigmoid sinus are skeletonized. The majority of the mastoid cavity is covered with erosive skin. MFD, middle fossa dura; SS, sigmoid sinus.



Fig. 11.79 The sinodural angle is opened with a large diamond burr. The drilling should be carried out from medial to lateral in this area (arrow).

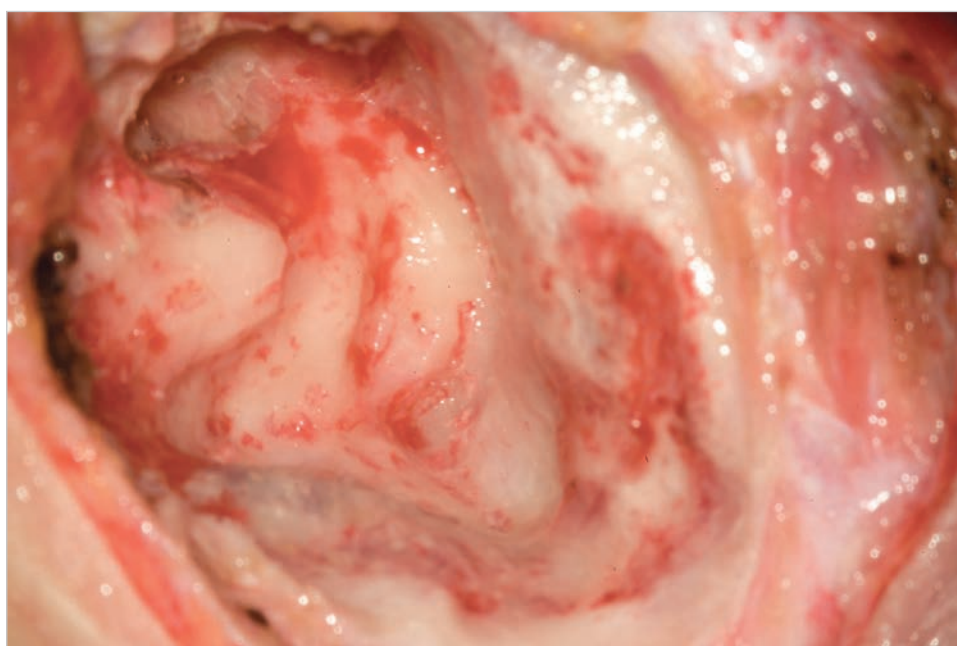


Fig. 11.80 The sinodural angle is opened, and residual cells in this area are removed.

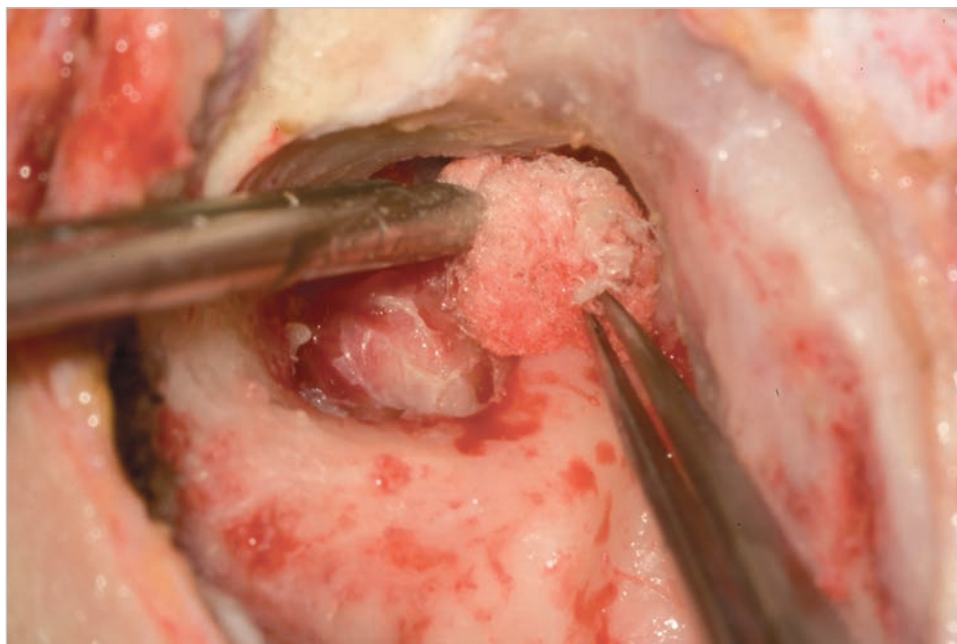


Fig. 11.81 The area of the tympanic segment of the facial nerve suspicious of residual skin is scrubbed with cottonoid. The medial wall of the tympanic cavity is still covered with thin skin at this moment.

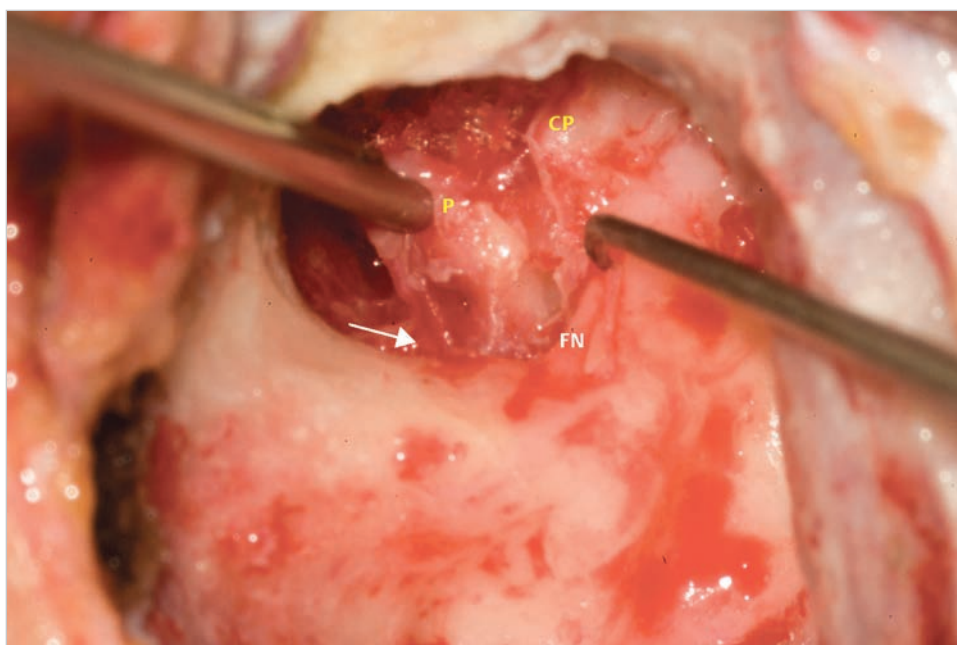


Fig. 11.82 The tympanic membrane adherent completely to the medial wall of the tympanic cavity is dissected with great care. The skin invaginating the tympanic sinus is shown (*arrow*). Dissection of the skin covering the area of the stapes is reserved until the last moment of this dissection. CP, cochleariform process; FN, facial nerve; P, promontory.

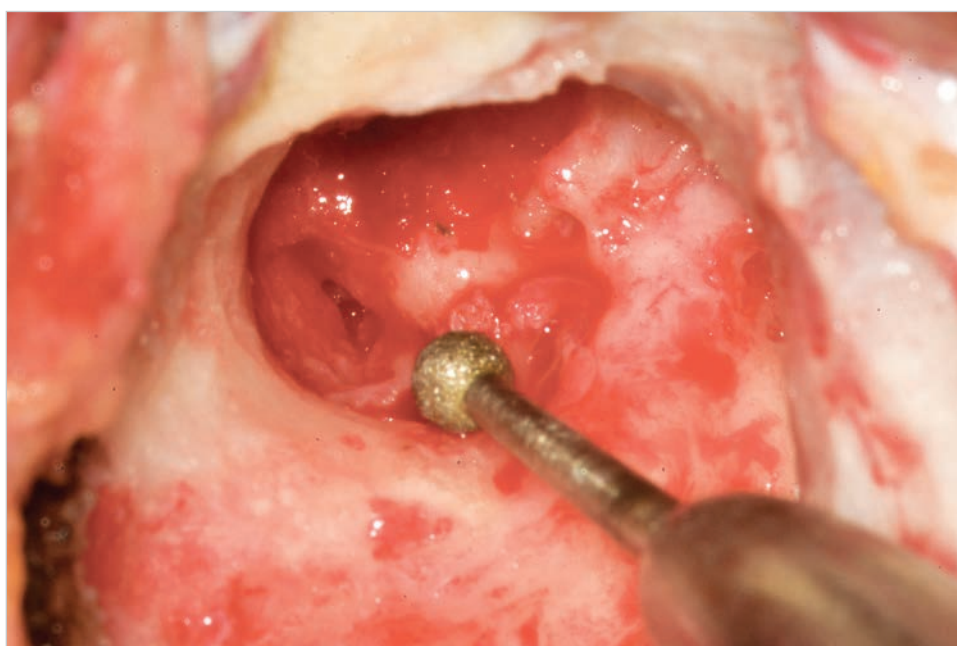


Fig. 11.83 To gain access to the tympanic sinus, the anterior face of the facial ridge is drilled with a large diamond burr. Ample irrigation is necessary to avoid thermal injury of the facial nerve.

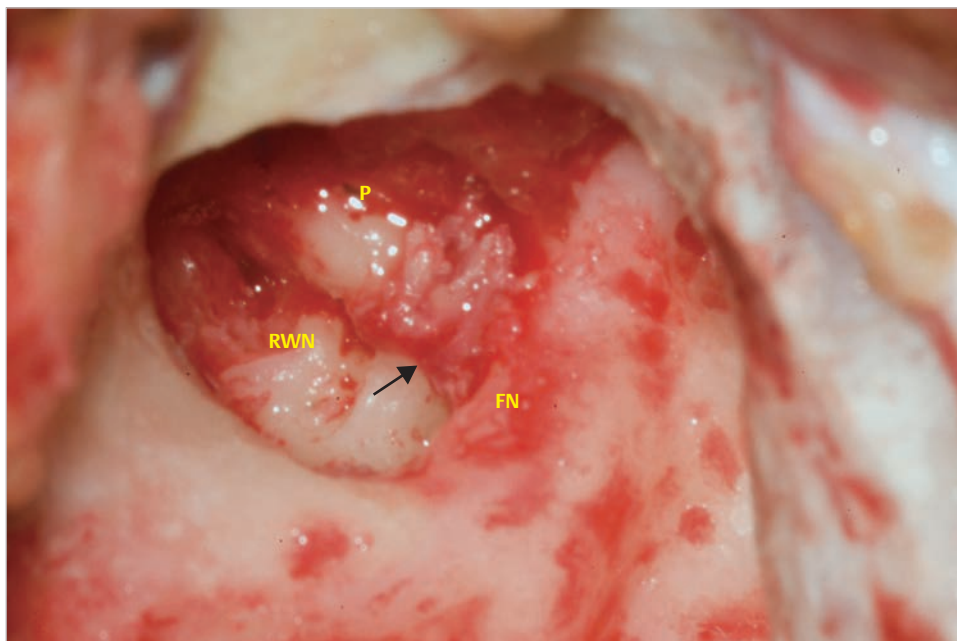


Fig. 11.84 After lowering the facial ridge fully, the skin in the tympanic sinus is removed. Note the wide access to the round window niche. The area of the stapes is still covered with adherent skin (*arrow*). FN, facial nerve; P, promontory; RWN, round window niche.

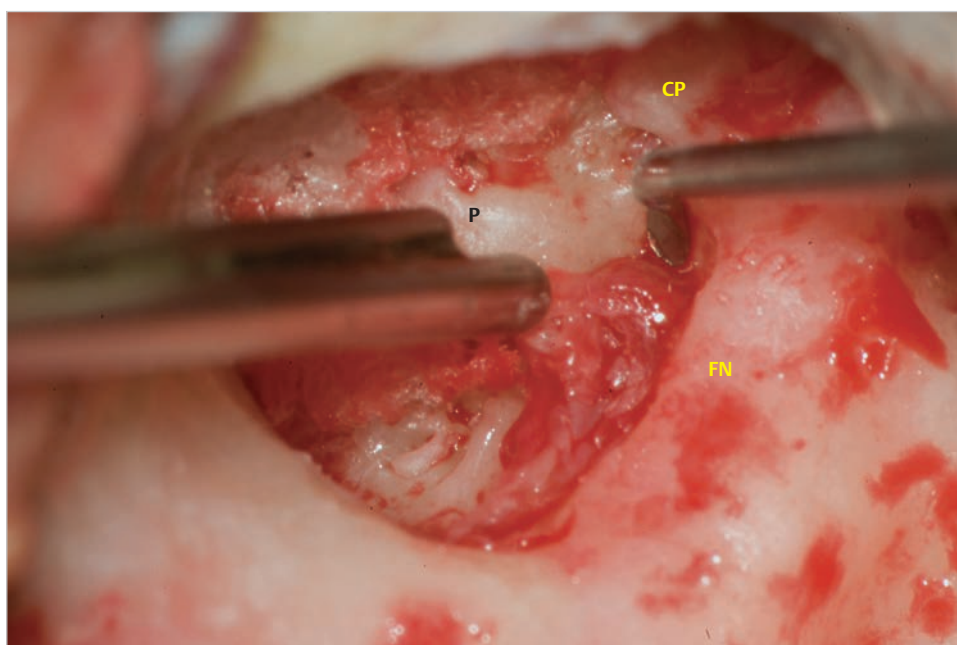


Fig. 11.85 The area of the stapes can be identified by searching the dip between the promontory and the facial nerve, posteroinferiorly to the cochleariform process. Dissection of the skin from the footplate of the stapes should be carried out along its long axis, in this case, from anterior to posterior. CP, cochleariform process; FN, facial nerve; P, promontory.

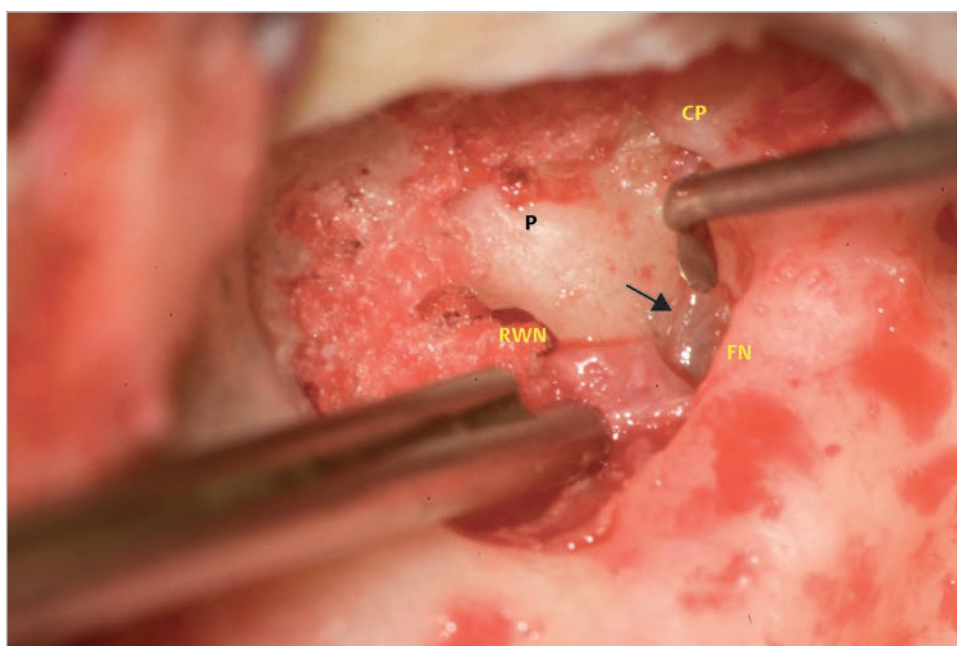


Fig. 11.86 The footplate is started to be seen. The superstructure is totally eroded. CP, cochleariform process; FN, facial nerve; P, promontory; RWN, round window niche.

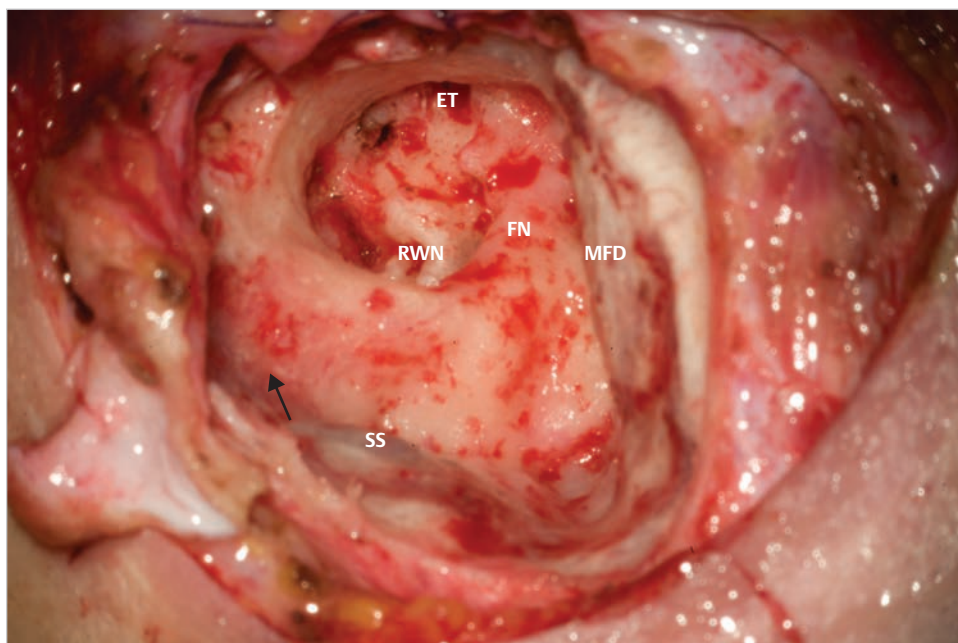


Fig. 11.87 The final shape of the cavity is shown. Note that all edges are removed, the facial ridge is lowered, and the air cells are sufficiently removed. ET, eustachian tube; FN, facial nerve; MFD, middle fossa dura; RWN, round window niche; SS, sigmoid sinus.

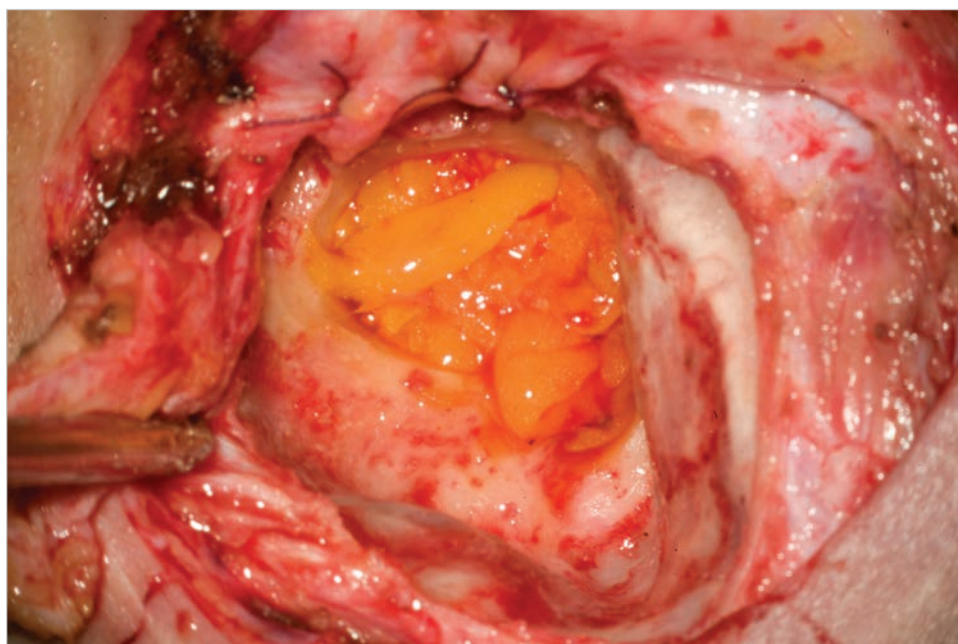


Fig. 11.88 After obliterating the eustachian tube, the cavity is packed with abdominal fat.

Case 11.8 (Right Ear)

See ► Fig. 11.89, ► Fig. 11.90, ► Fig. 11.91, ► Fig. 11.92, ► Fig. 11.93, ► Fig. 11.94, ► Fig. 11.95, ► Fig. 11.96, ► Fig. 11.97.

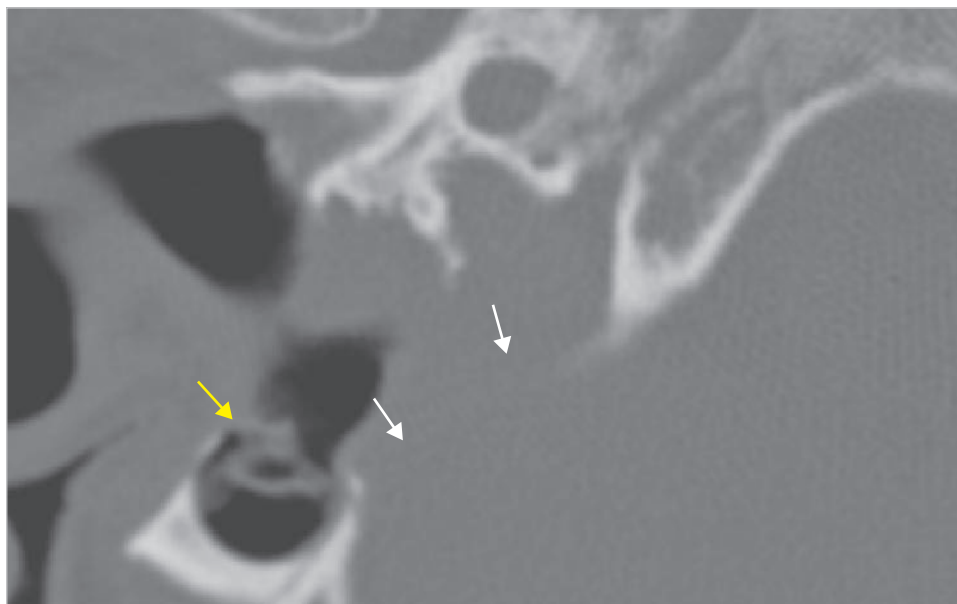


Fig. 11.89 The patient underwent middle ear surgery elsewhere, and intractable otorrhea follows. The axial CT shows extensive destruction of temporal bone and accumulation of debris in inaccessible area (*yellow arrow*). The posterior fossa dura and the area of the sigmoid sinus are exposed extensively (*white arrows*).

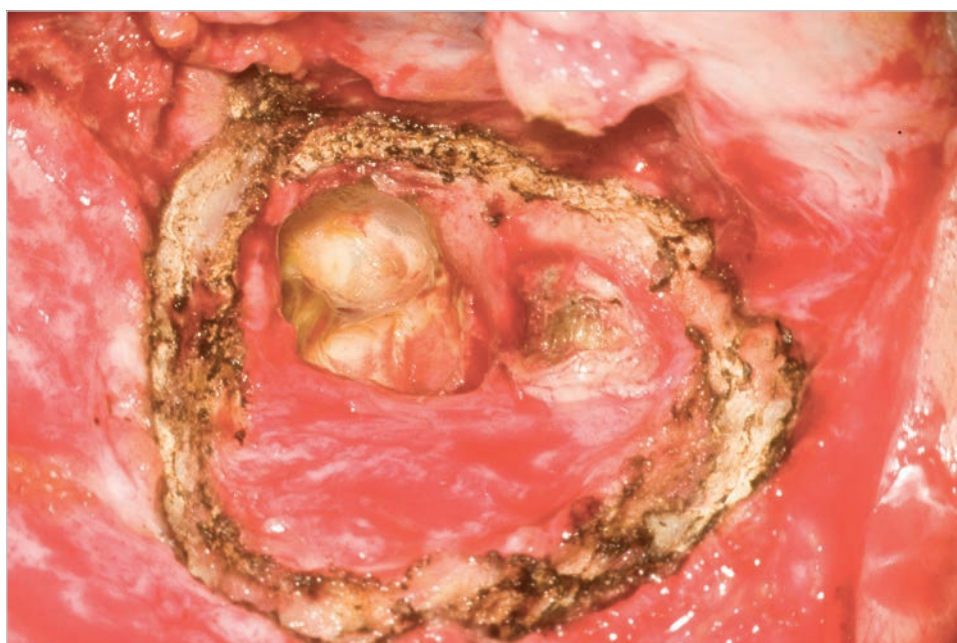


Fig. 11.90 To remove all inflammatory soft tissue and skin covering the cavity, the bone around the cavity is exposed with electrocautery. Before this procedure, presence of underlying bone should be verified by careful palpation.

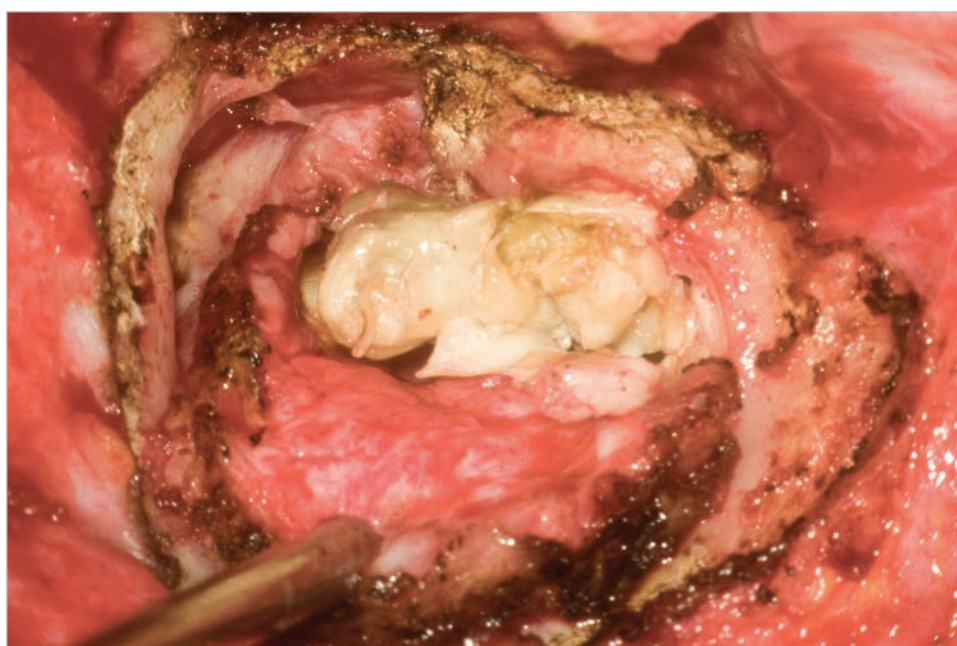


Fig. 11.91 The mastoid cavity is filled with a copious amount of debris.

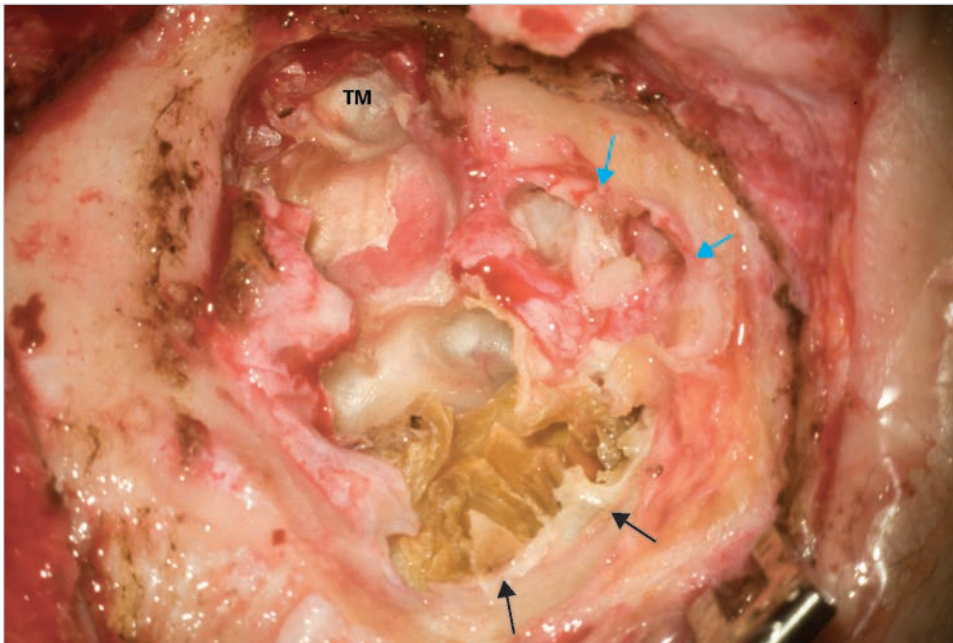


Fig. 11.92 Removal of cortical bone is carried out to enlarge access to the cholesteatoma. The cholesteatoma goes far posteriorly to reach the area of the retrosigmoid cells (*black arrows*), and far inferiorly to fill very large cells in the mastoid tip (*blue arrows*). Note the distance from the tympanic membrane. TM, tympanic membrane.

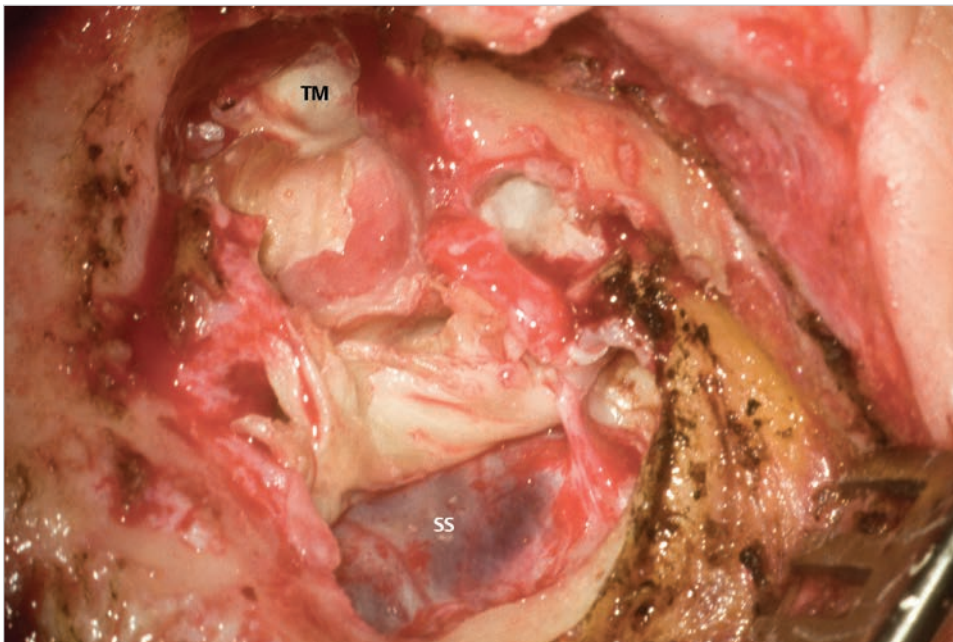


Fig. 11.93 The matrix is dissected from the retrosigmoid area and the large sigmoid sinus is started to be exposed. SS, sigmoid sinus; TM, tympanic membrane.

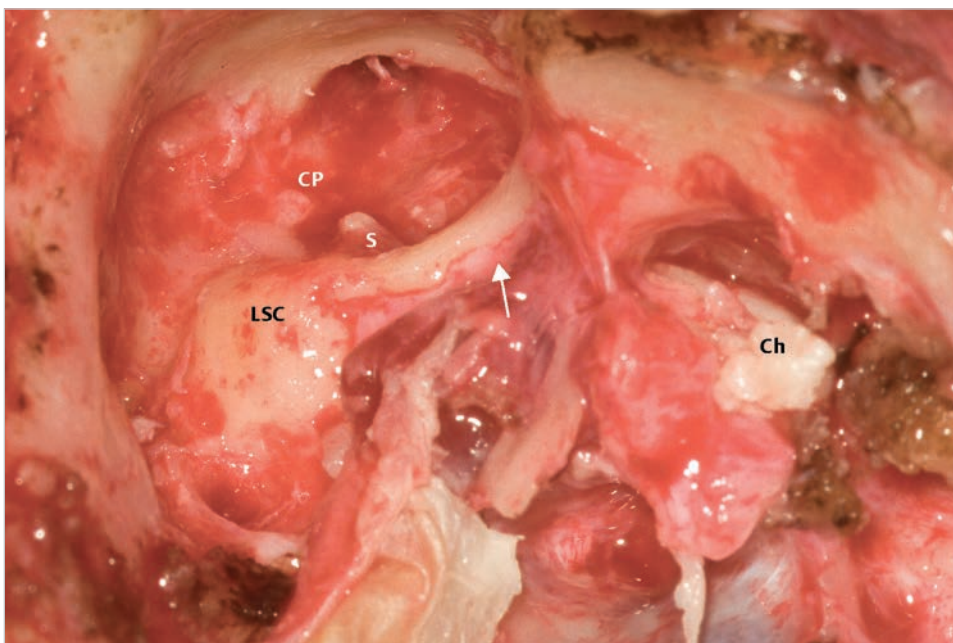


Fig. 11.94 Closer view of the area of the tympanic cavity. The matrix and granulation tissue are detached from the facial ridge. The cholesteatoma fills very large cells in the mastoid tip, and exposes the mastoid segment of the facial nerve (*arrow*). Ch, cholesteatoma; CP, cochleariform process; LSC, lateral semicircular canal; S, stapes.

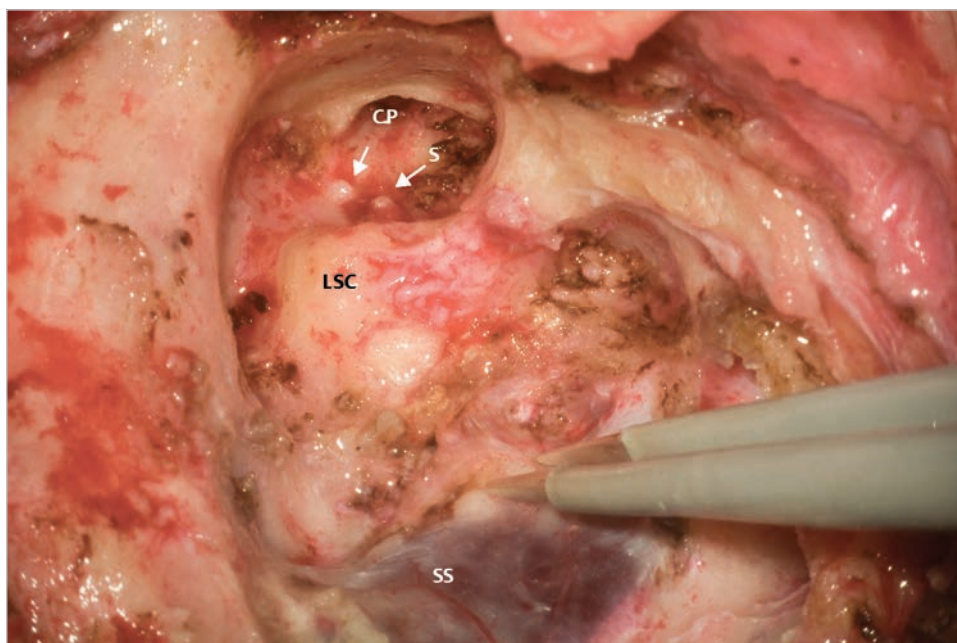


Fig. 11.95 Removal of cholesteatoma is completed. To verify total removal of the cholesteatoma, the area suspicious for leaving matrix should be coagulated with bipolar. CP, cochleariform process; LSC, lateral semicircular canal; S, stapes; SS, sigmoid sinus.

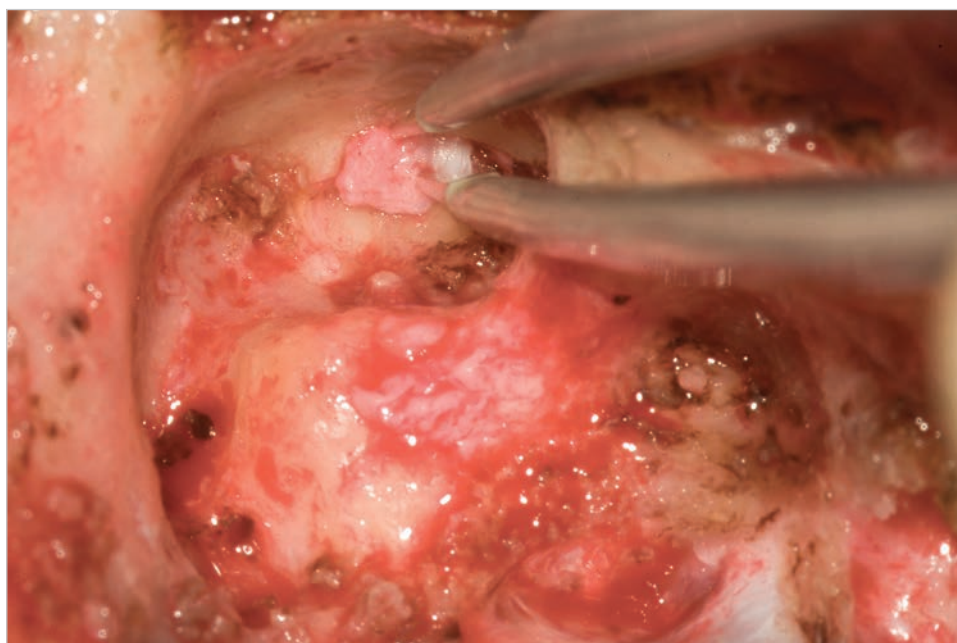


Fig. 11.96 The eustachian tube is closed with pieces of periosteum, and the cavity is packed with abdominal fat.

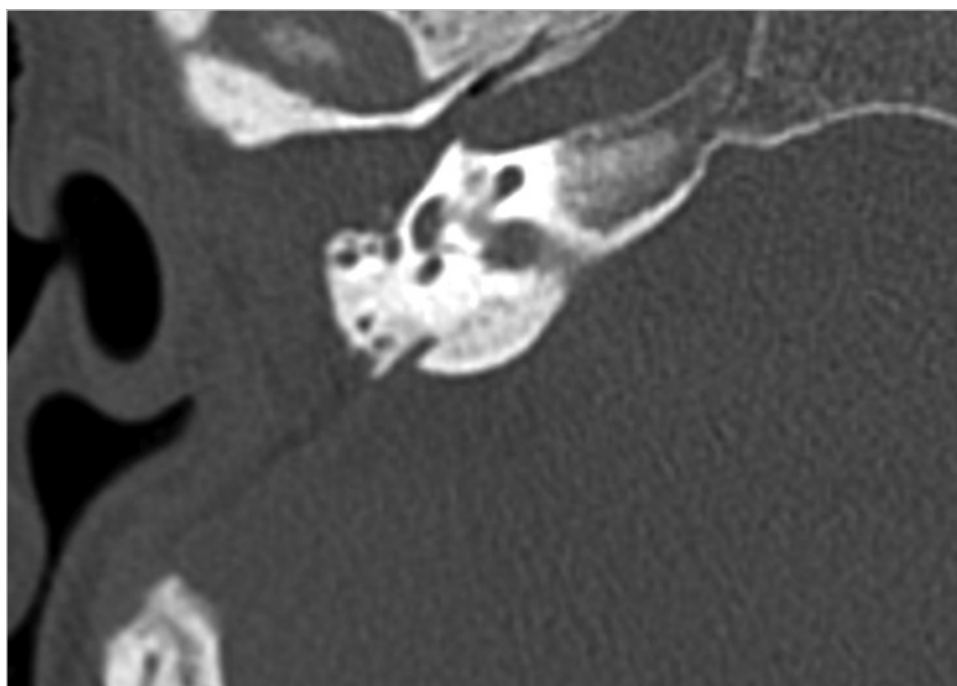


Fig. 11.97 The postoperative CT is shown. The cavity is closed with abdominal fat.

Case 11.9 (Left Ear)

See ►Fig. 11.98, ►Fig. 11.99, ►Fig. 11.100, ►Fig. 11.101, ►Fig. 11.102, ►Fig. 11.103, ►Fig. 11.104, ►Fig. 11.105, ►Fig. 11.106, ►Fig. 11.107, ►Fig. 11.108, ►Fig. 11.109, ►Fig. 11.110, ►Fig. 11.111.



Fig. 11.98 This 14-year-old patient underwent two cholesteatoma surgeries resulting in a draining cavity with no serviceable hearing. An otoscopic examination shows recurrence of cholesteatoma in the depth of the mastoid tip without possibility of cleaning. In the axial CT, large cholesteatoma without aeration of the middle ear cleft is seen. In the coronal view, note the protrusion in the middle fossa plate with exposure of the dura (*arrow*). C, cochlea; Ch, cholesteatoma; ET, eustachian tube; LSC, lateral semicircular canal; PSC, posterior semicircular canal; SSC, superior semicircular canal.



Fig. 11.99 The lateral face of the temporal bone is exposed via a retroauricular incision. For sufficient exposure, the skin incision should be carried out more posteriorly than usual in middle ear surgery. Elevation of the musculoperiosteal layer opened the cavity filled with cholesteatoma.

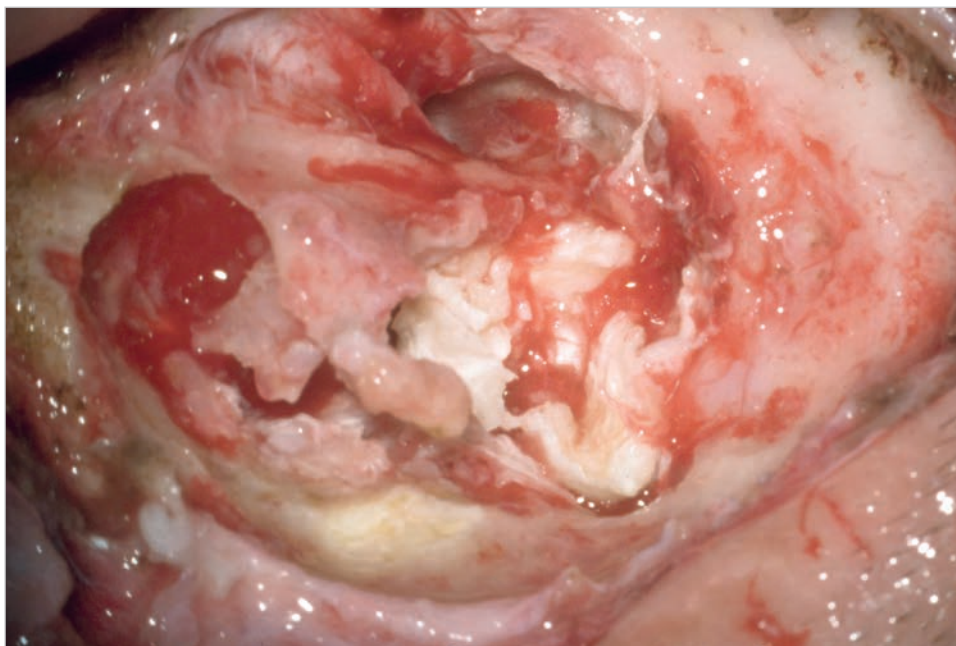


Fig. 11.100 The mastoidectomy has been enlarged inferiorly to open completely the cells in the mastoid tip.

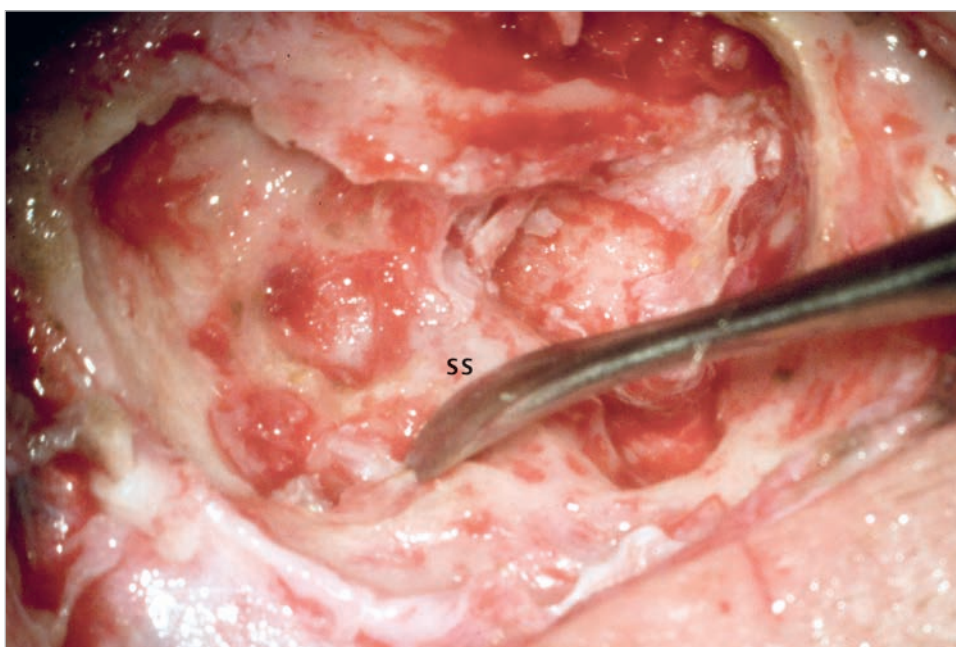


Fig. 11.101 The cholesteatoma invaginated into large retrosigmoid cells is indicated by the instrument. SS, sigmoid sinus.

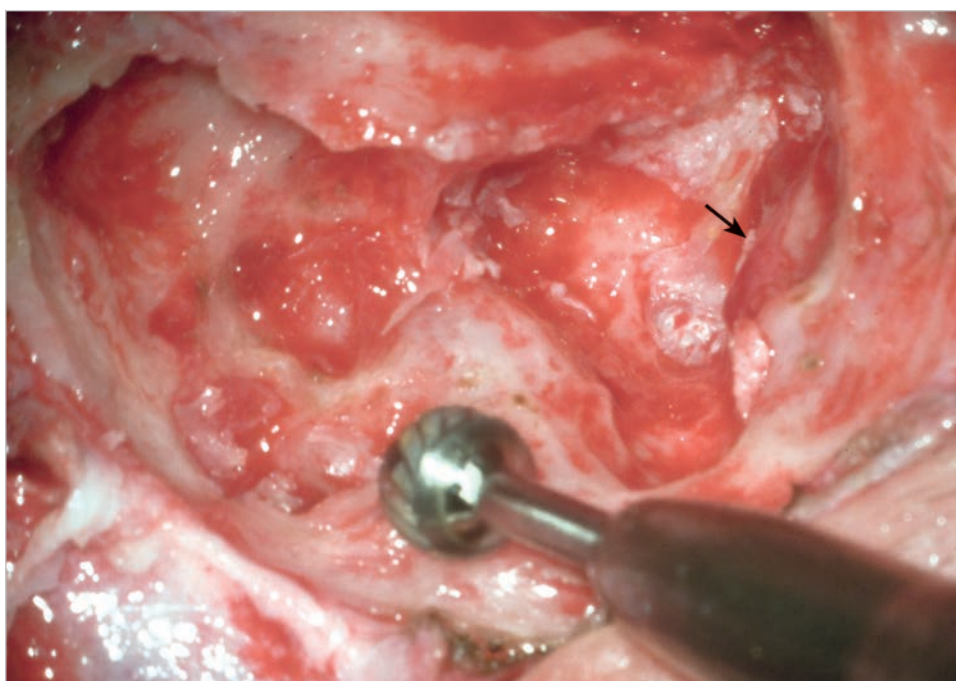


Fig. 11.102 The retrosigmoid cells were removed with a large cutting bur. The arrow indicates the protrusion of the middle fossa dura seen in the CT image.

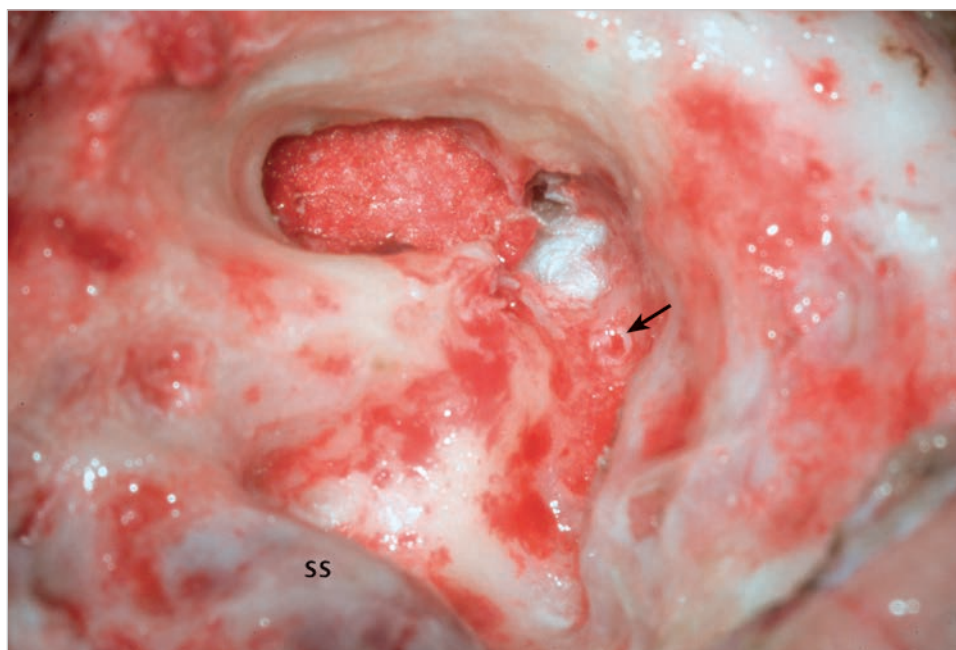


Fig. 11.103 Removal of cholesteatoma from the mastoid is completed. The posterior canal wall is drilled, and the meatal skin is removed with the tympanic membrane. The canal is drilled to ensure complete removal of the skin. The tympanic cavity is packed with a piece of cottonoid to stop bleeding. Cholesteatoma still remains in the attic and in a cell located anteriorly to the superior semicircular canal (arrow). SS, sigmoid sinus.

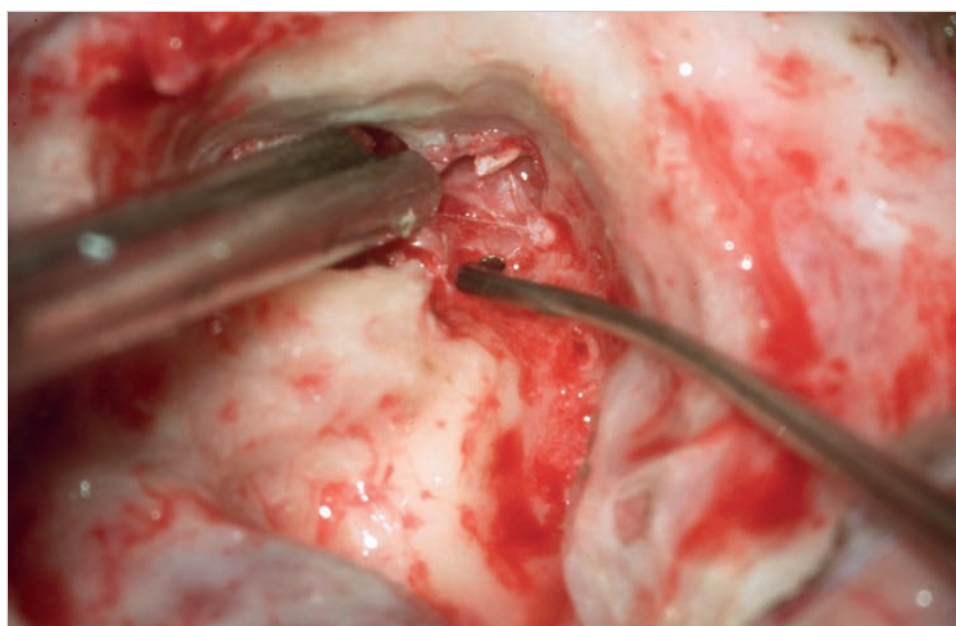


Fig. 11.104 The facial nerve exposed in the medial wall of the attic is indicated with the tympanic sinus hook.

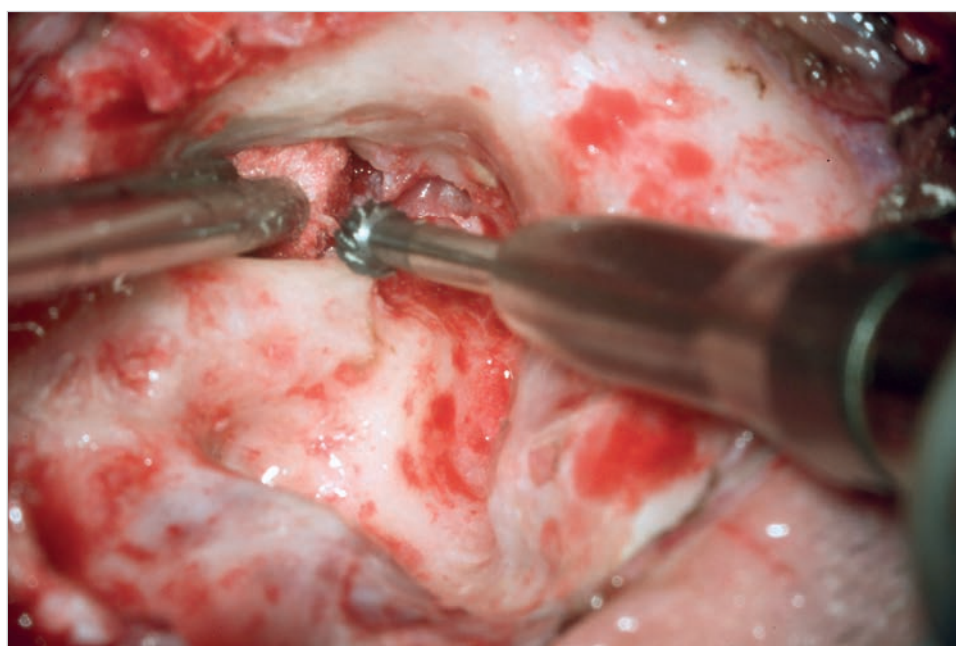


Fig. 11.105 The facial ridge is lowered with a cutting burr. The burr should be moved parallel to the facial nerve. Two buttresses protruding from the anterior wall and the facial ridge should be removed.

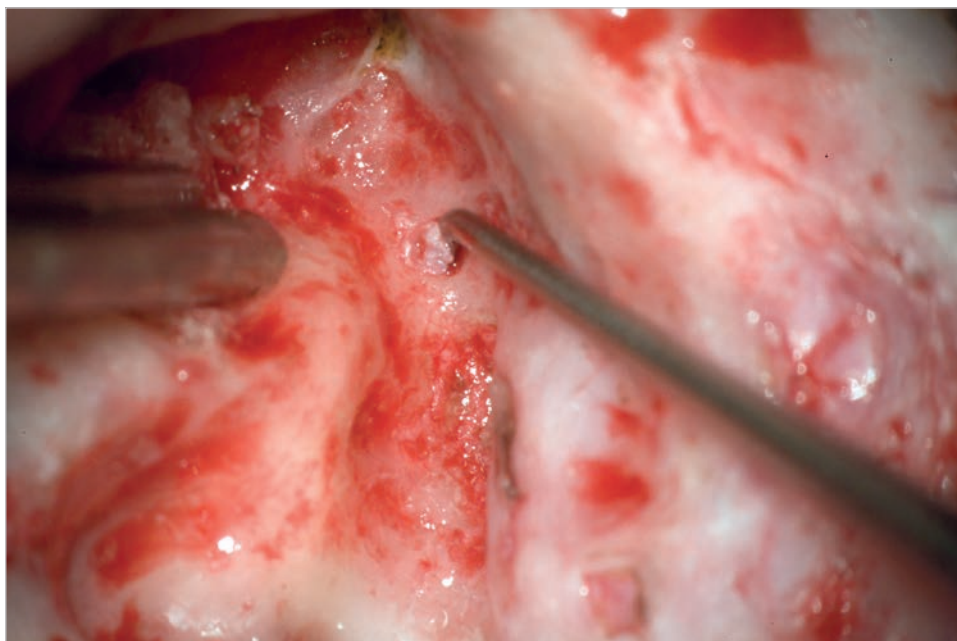


Fig. 11.106 The cholesteatoma matrix invaginating a small deep cell located anteriorly to the ampulla of the superior semicircular canal is dissected.

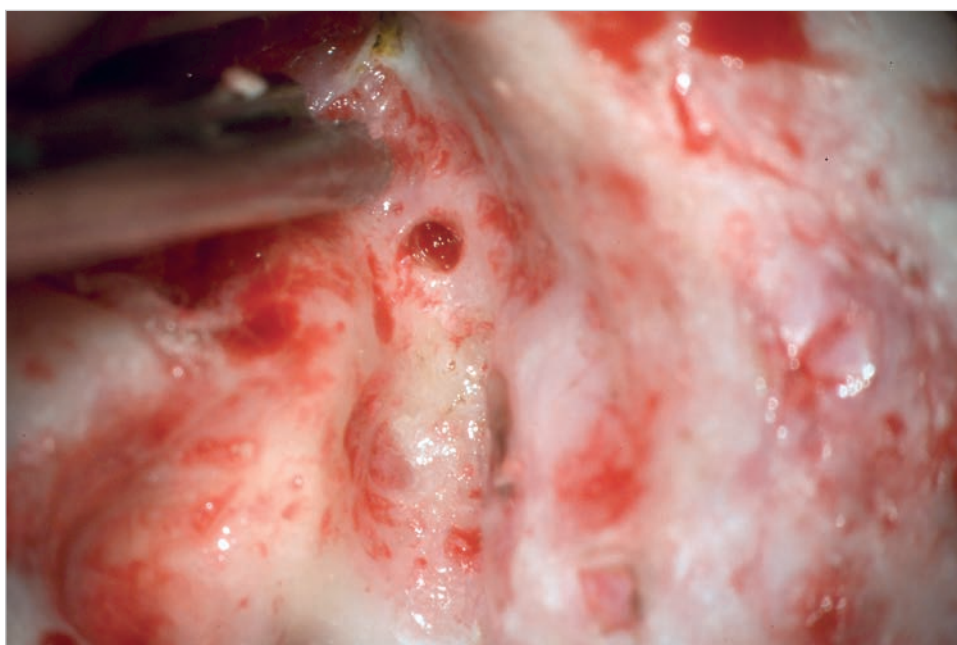


Fig. 11.107 A small piece of matrix remained in the cell is shown.

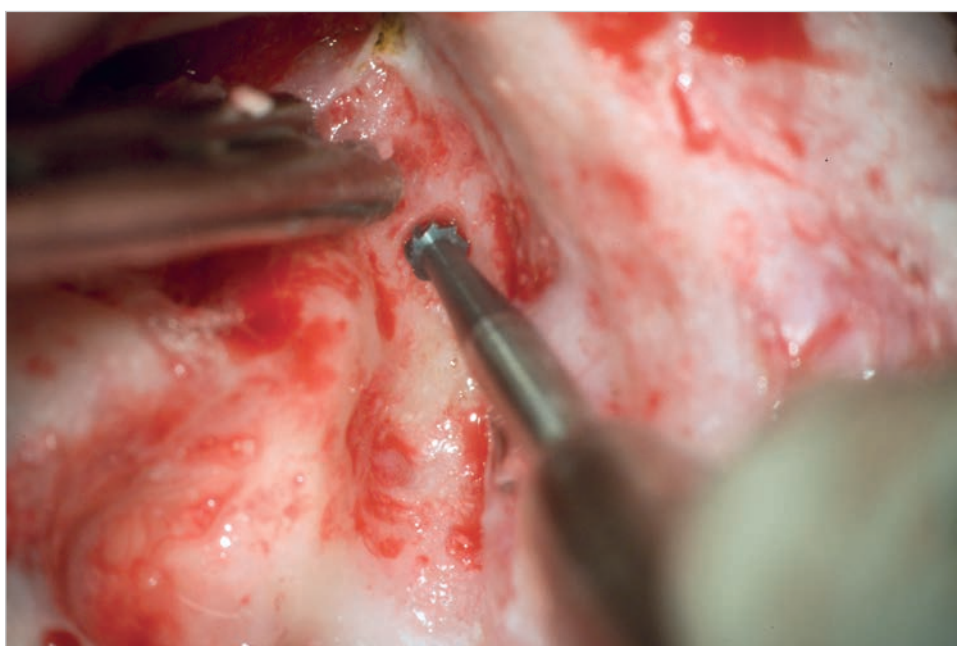


Fig. 11.108 The cell should be drilled, taking care not to open the superior semicircular canal. A small cutting burr is used to avoid burying cholesteatoma matrix in the cell with bone dust.



Fig. 11.109 The cell has been drilled completely to remove cholesteatoma.



Fig. 11.110 The final shape of the cavity is shown. The cavity is rounded and air cells are removed sufficiently to eliminate possibility of leaving some skin behind. As a result, the sigmoid sinus and the middle fossa are skeletonized.

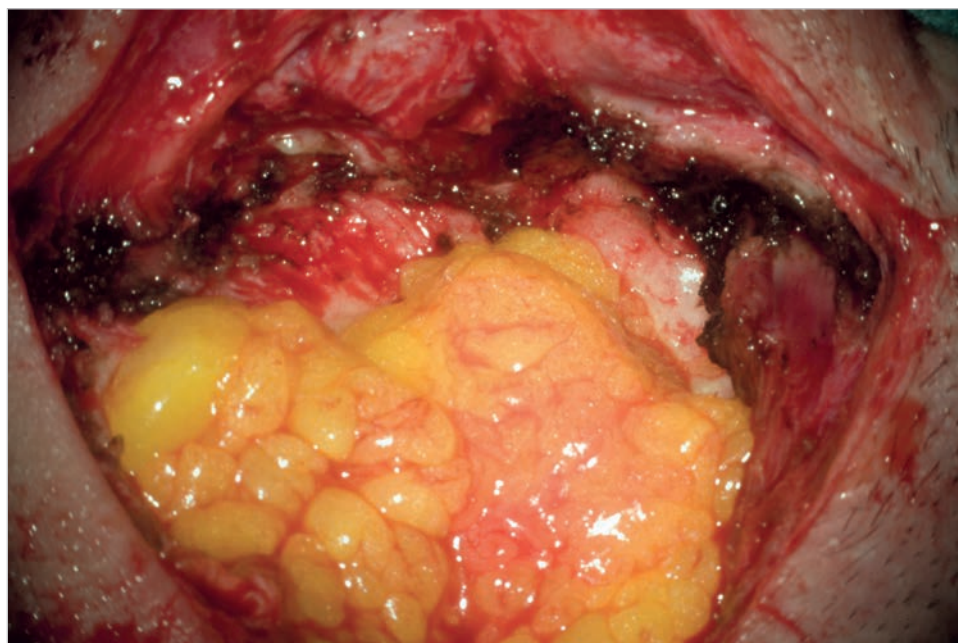


Fig. 11.111 The cavity is packed with pieces of abdominal fat.

Case 11.10 (Left Ear)

See ►Fig. 11.112, ►Fig. 11.113, ►Fig. 11.114, ►Fig. 11.115,
►Fig. 11.116, ►Fig. 11.117, ►Fig. 11.118, ►Fig. 11.119,
►Fig. 11.120, ►Fig. 11.121, ►Fig. 11.122.

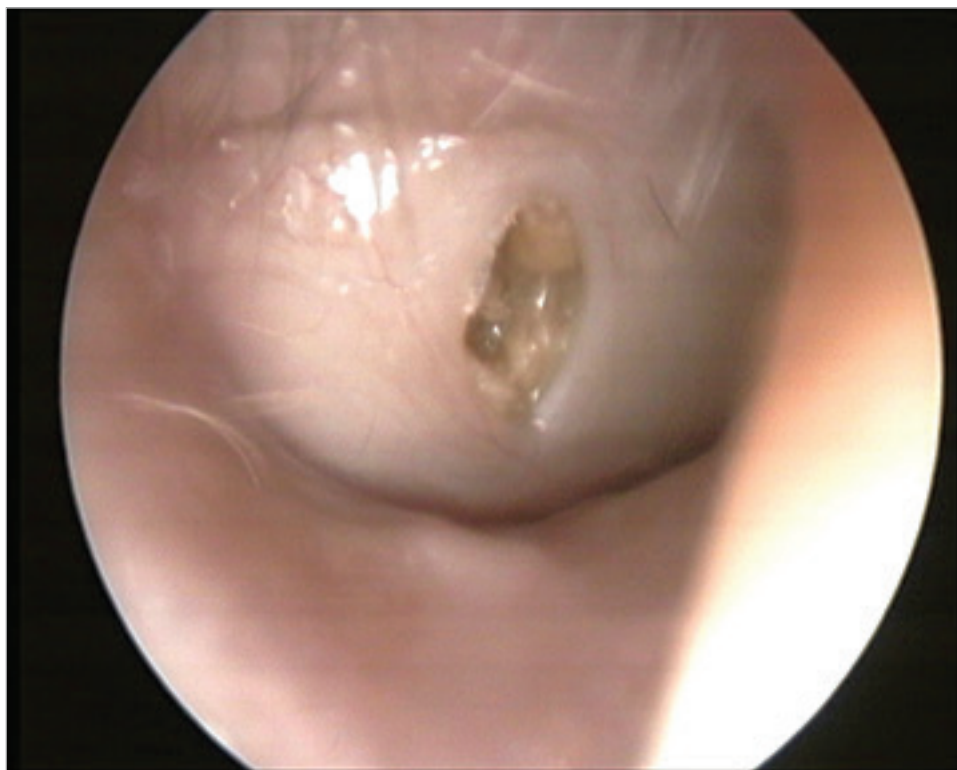


Fig. 11.112 The patient underwent cholesteatoma surgery elsewhere without restoration of hearing. Otoscopy shows closure of the external auditory canal with a bulge of the superior wall. A cut in the bulge revealed presence of debris medially.

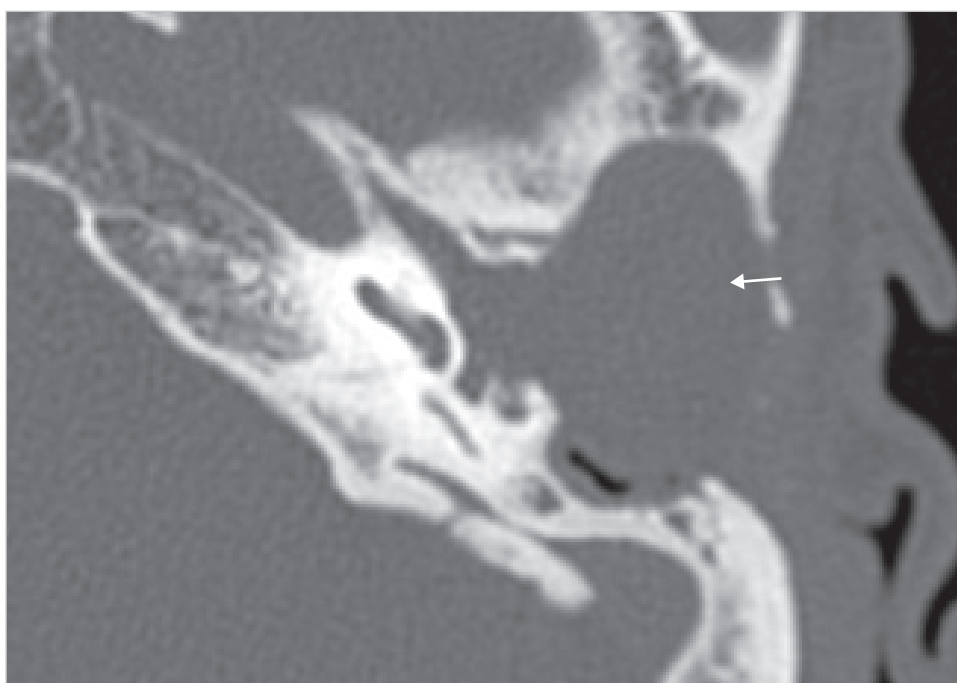


Fig. 11.113 The axial CT shows round-shaped erosion growing from the superior part of the cavity. Significant erosion of the anterior wall of the external auditory canal is seen (*arrow*). No aeration is identified in the tympanic cavity.

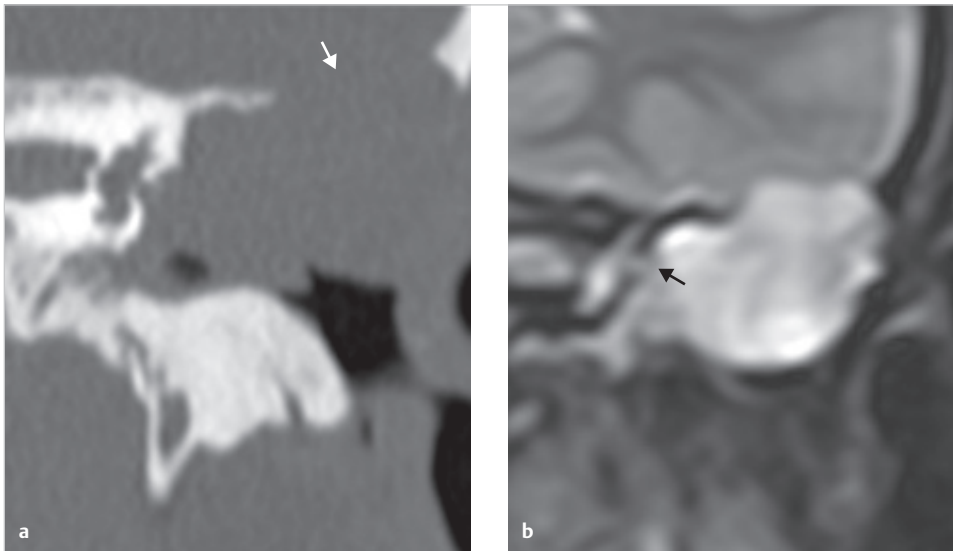


Fig. 11.114 The coronal CT shows presence of massive soft tissue superiorly to the external auditory canal (a). The middle fossa dura is widely exposed (white arrow), and the superior bony wall of the meatus is lost. The T2-weighted image of MRI demonstrates high signal, corresponding to cholesteatoma (b). Presence of labyrinthine fistula in the lateral semicircular canal is demonstrated in the MRI (black arrow).

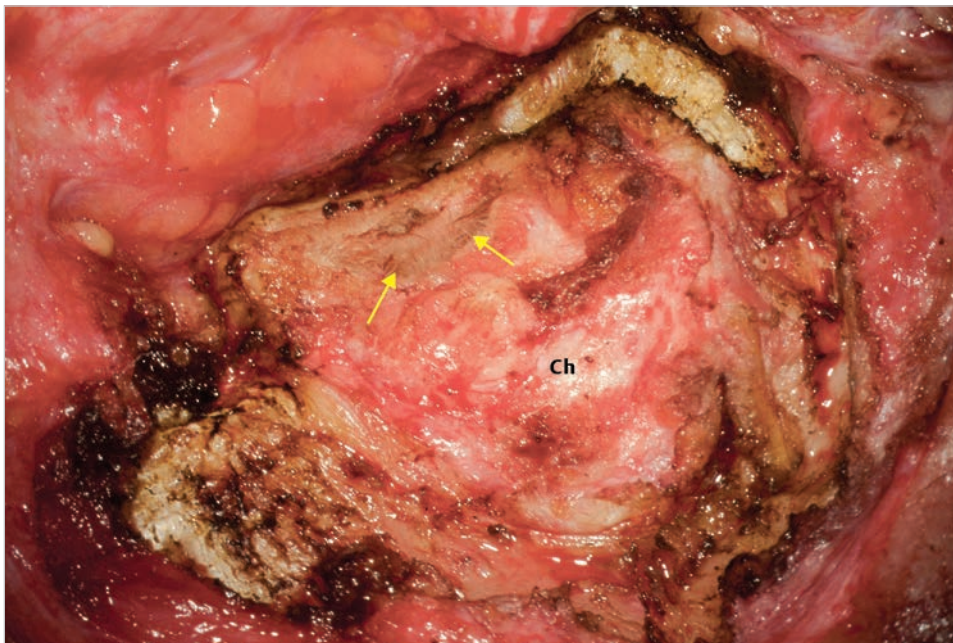


Fig. 11.115 Retroauricular incision is conducted, and the skin is elevated in such way that the scar tissue covering the lateral aspect of cholesteatoma is preserved, not to leave any skin laterally. The arrows indicate the opening of the cartilaginous portion of the external auditory canal. Ch, cholesteatoma.

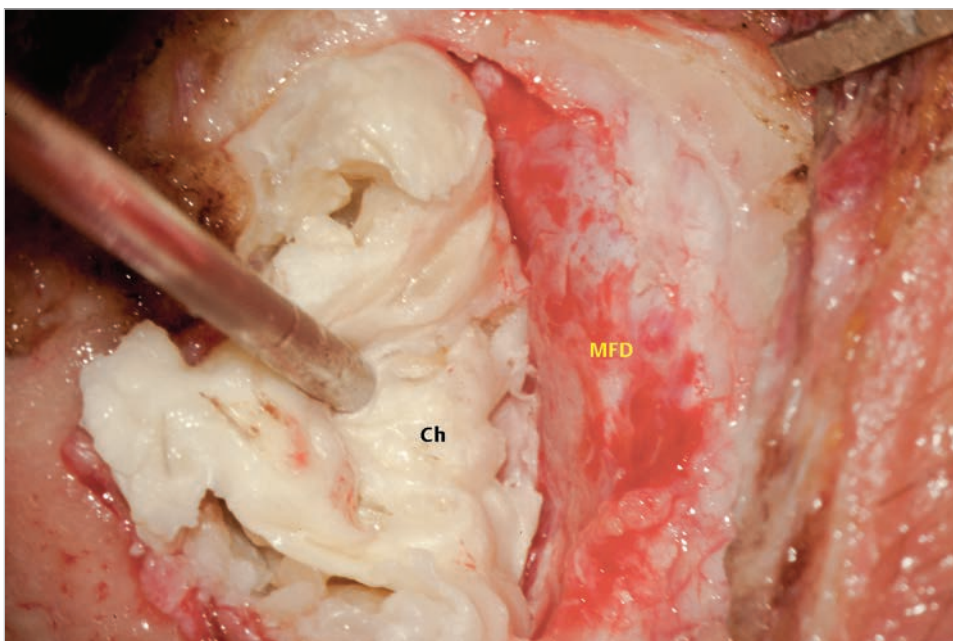


Fig. 11.116 Opening of the scar tissue exposed large cholesteatoma filling the mastoid. Superiorly, the middle fossa dura is exposed extensively. Ch, cholesteatoma; MFD, middle fossa dura.

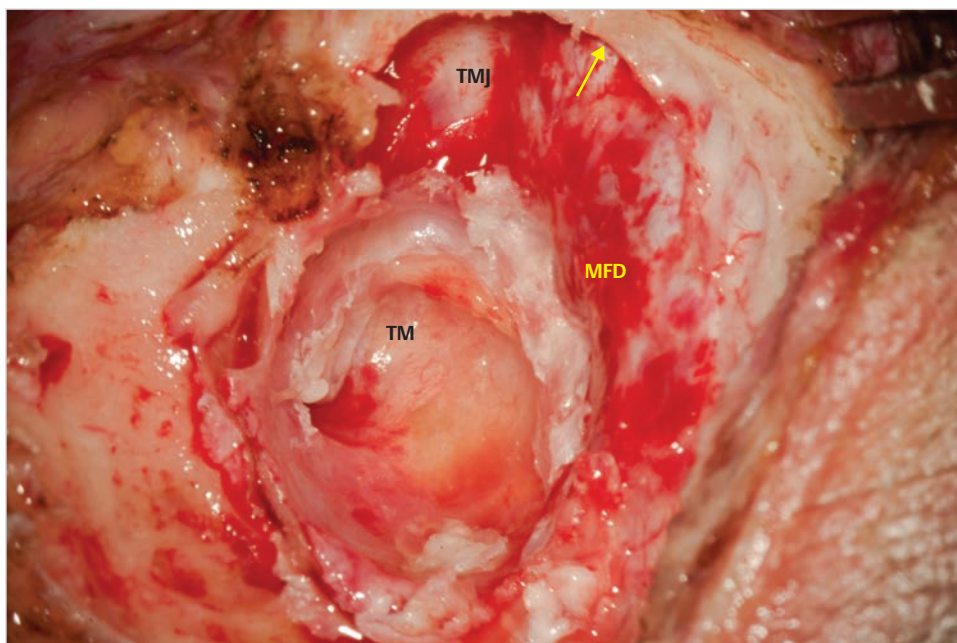


Fig. 11.117 The debris is evacuated to evaluate extension of the cholesteatoma. The tympanic membrane totally adherent to the medial wall of the tympanic cavity is seen. Note significant erosion of the anterior wall resulting in extensive exposure of the middle fossa dura and the temporomandibular joint. MFD, middle fossa dura; TM, tympanic membrane; TMJ, temporomandibular joint.

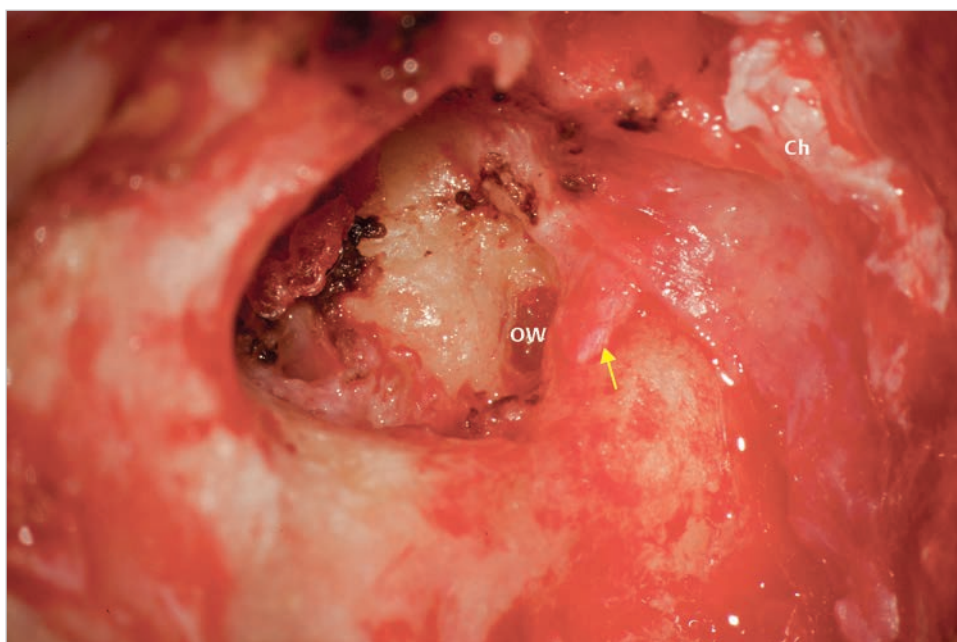


Fig. 11.118 The adherent tympanic membrane is detached from the medial wall of the tympanic cavity. The tympanic segment of the facial nerve exposed under the skin is seen (arrow). Ch, cholesteatoma; OW, oval window.

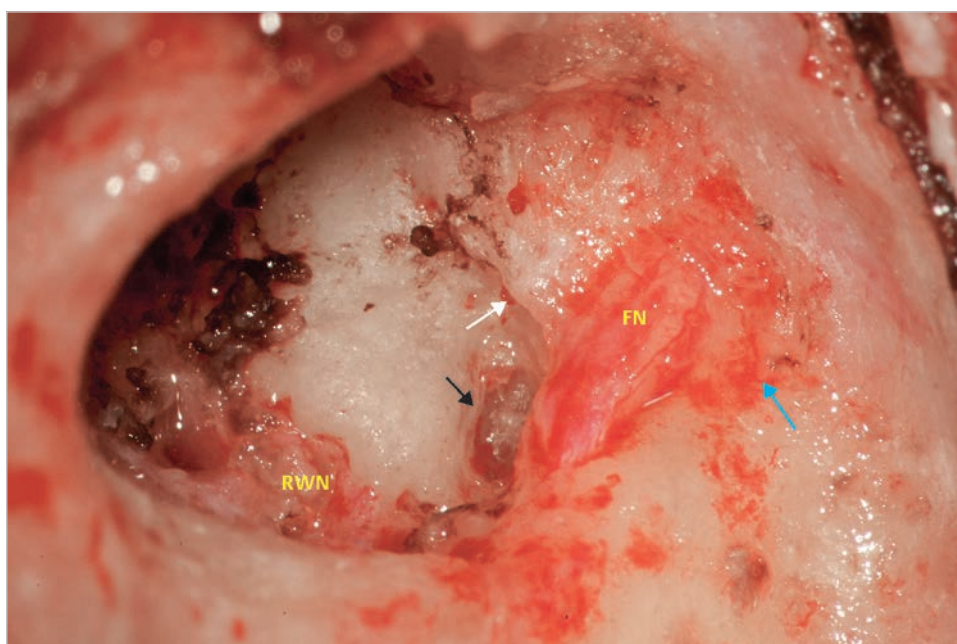


Fig. 11.119 Closer view after removing all skin from the tympanic cavity. The extensively exposed facial nerve runs just superiorly to the cochleariform process (white arrow). The lateral semicircular canal is blue-lined, but not opened (blue arrow). Footplate in the oval window is identified under the facial nerve (black arrow). The round window niche is filled with scar tissue. FN, facial nerve; RWN, round window niche.

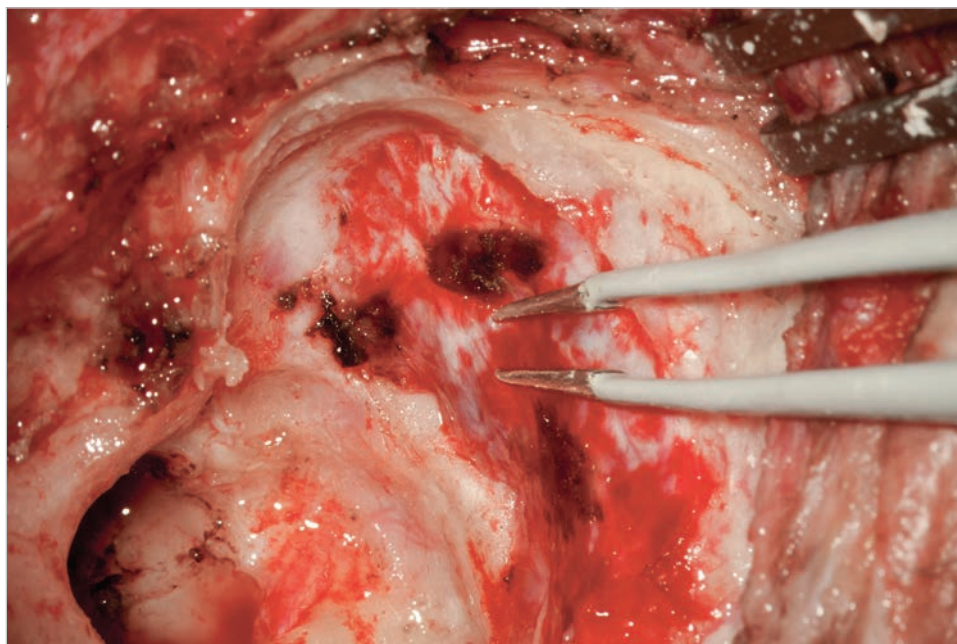


Fig. 11.120 Failure in enbloc removal of the matrix due to its thin and adherent nature resulted in suspicion of residual skin on the middle fossa dura. Bipolar coagulation should be applied to such area.

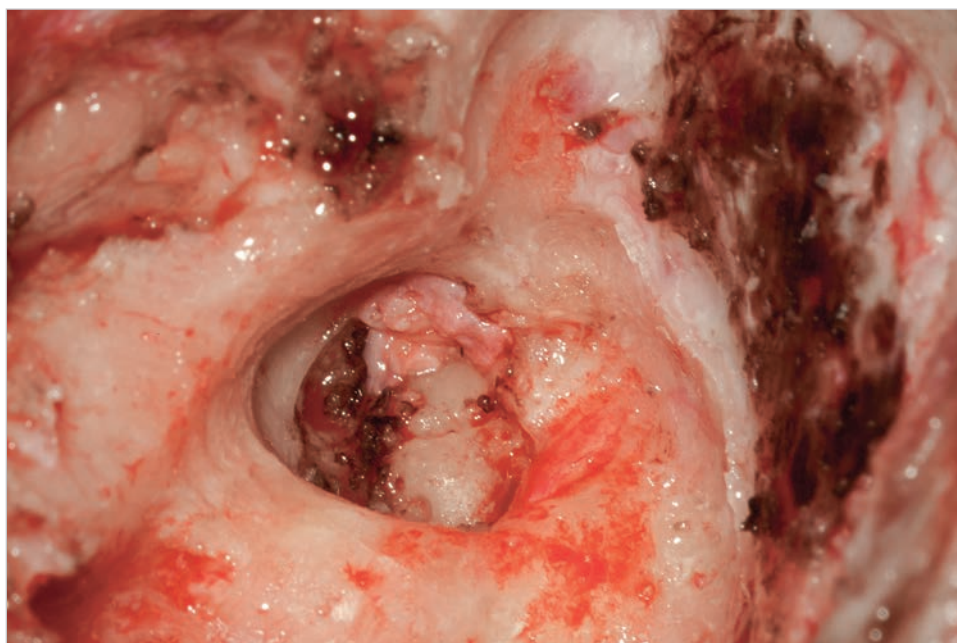


Fig. 11.121 After verifying eradication of all skins from the cavity, the eustachian tube is obliterated with pieces of periosteum.

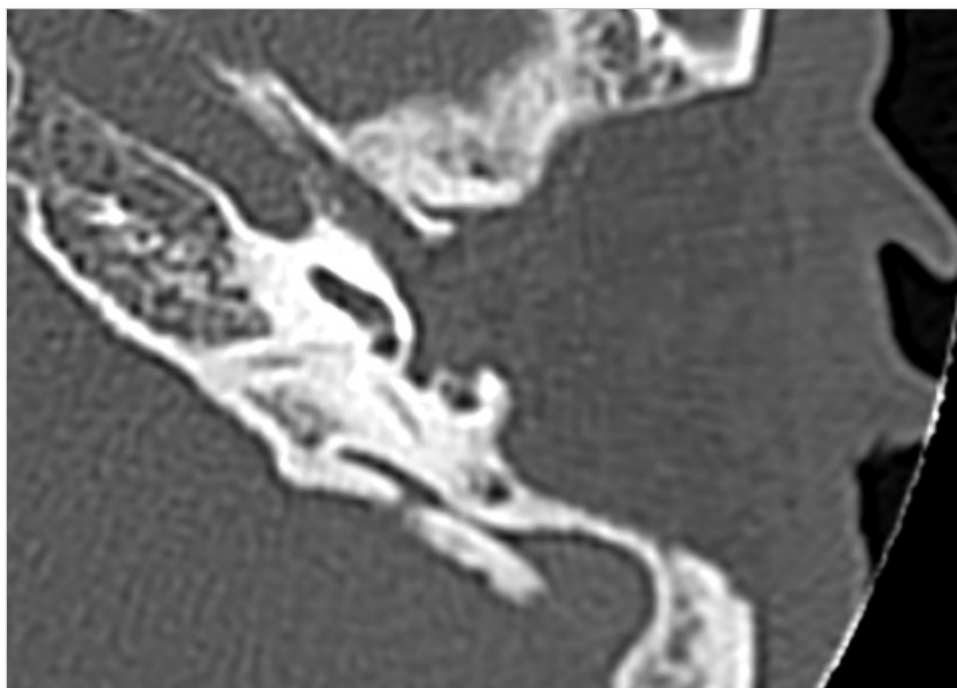


Fig. 11.122 The postoperative CT shows enlarged and rounded cavity packed with abdominal fat.

Case 11.11 (Left Ear)

See ▶Fig. 11.123, ▶Fig. 11.124, ▶Fig. 11.125, ▶Fig. 11.126,
▶Fig. 11.127, ▶Fig. 11.128, ▶Fig. 11.129, ▶Fig. 11.130,
▶Fig. 11.131, ▶Fig. 11.132, ▶Fig. 11.133, ▶Fig. 11.134.

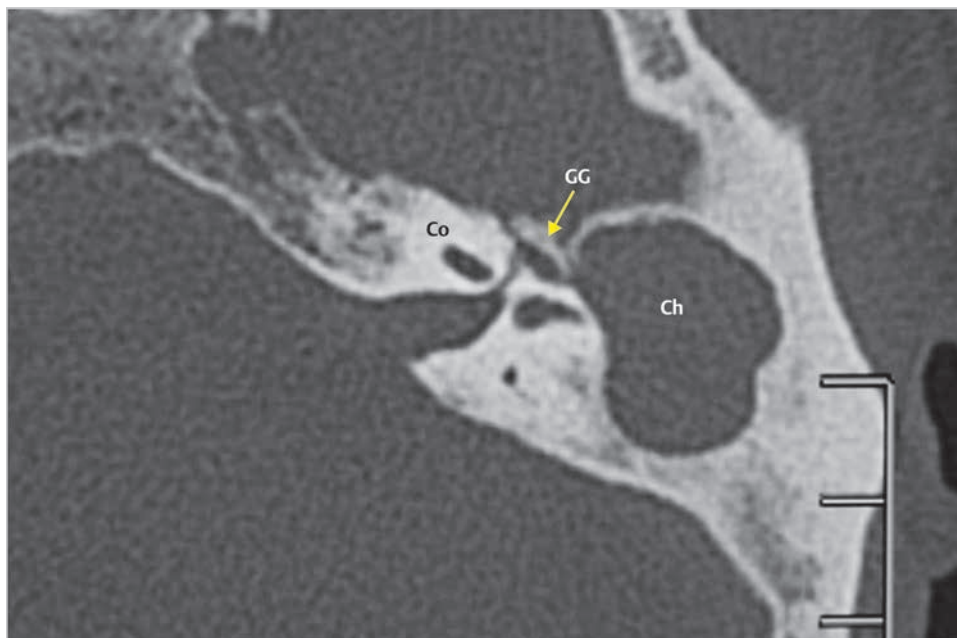


Fig. 11.123 A case of recurrent cholesteatoma in the open cavity is shown. The axial CT at the level of the geniculate ganglion shows round-shaped soft tissue density with expansive bone erosion in the middle ear. Ch, cholesteatoma; Co, cochlea; GG, geniculate ganglion.

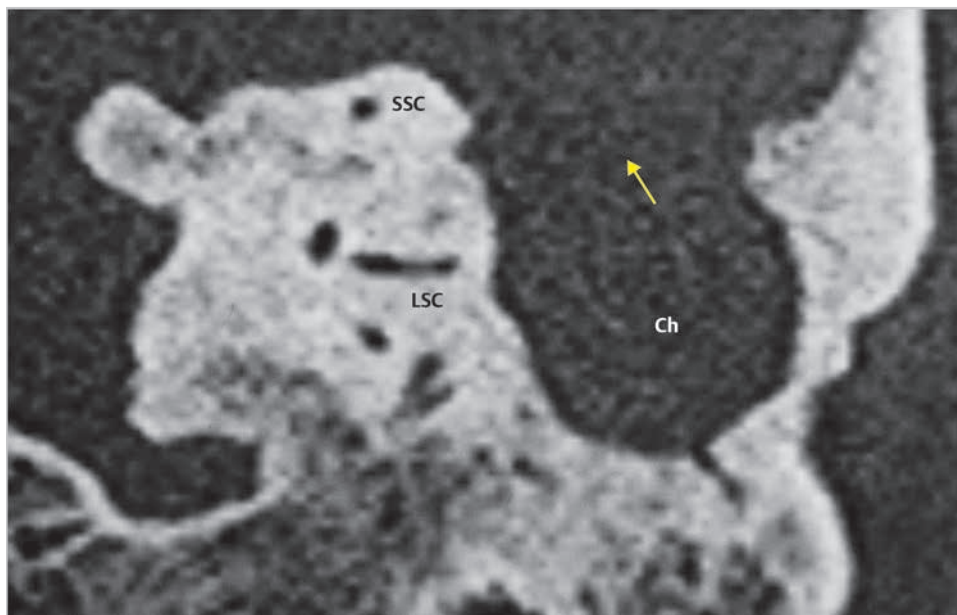


Fig. 11.124 In coronal view, an extensive bony defect in the tegmen of the mastoid is demonstrated (arrow). The CT shows possible presence of meningoencephalic herniation in the mastoid. Ch, cholesteatoma; LSC, lateral semicircular canal; SSC, superior semicircular canal.

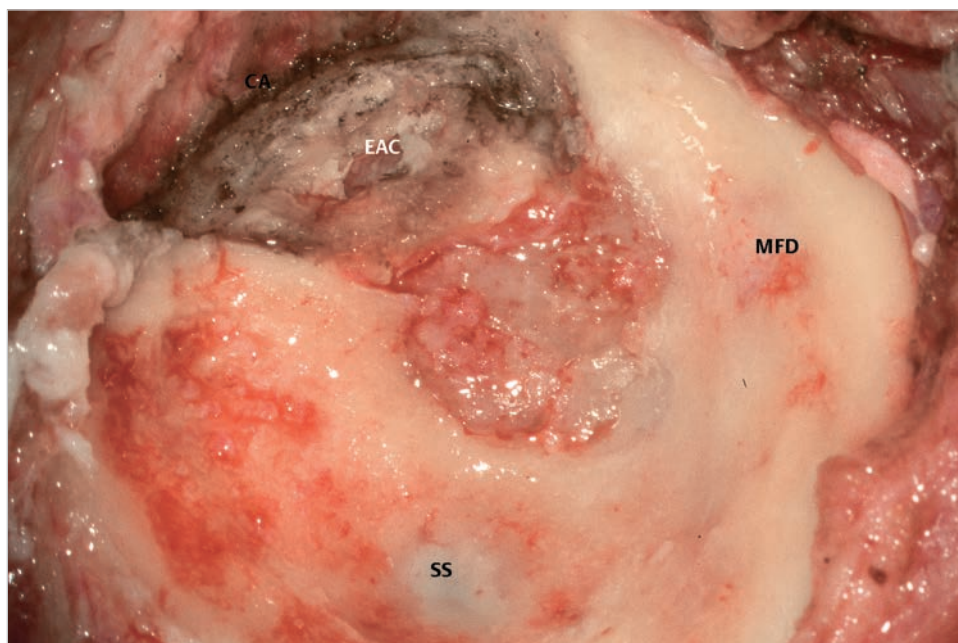


Fig. 11.125 Via retroauricular incision, the external auditory canal is transected. At the beginning of mastoidectomy, the middle fossa dura and the sigmoid sinus are identified superiorly and posteriorly, respectively. Tick scar tissue lining cholesteatoma is started to be identified between these structures. EAC, external auditory canal; MFD, middle fossa dura; SS, sigmoid sinus.

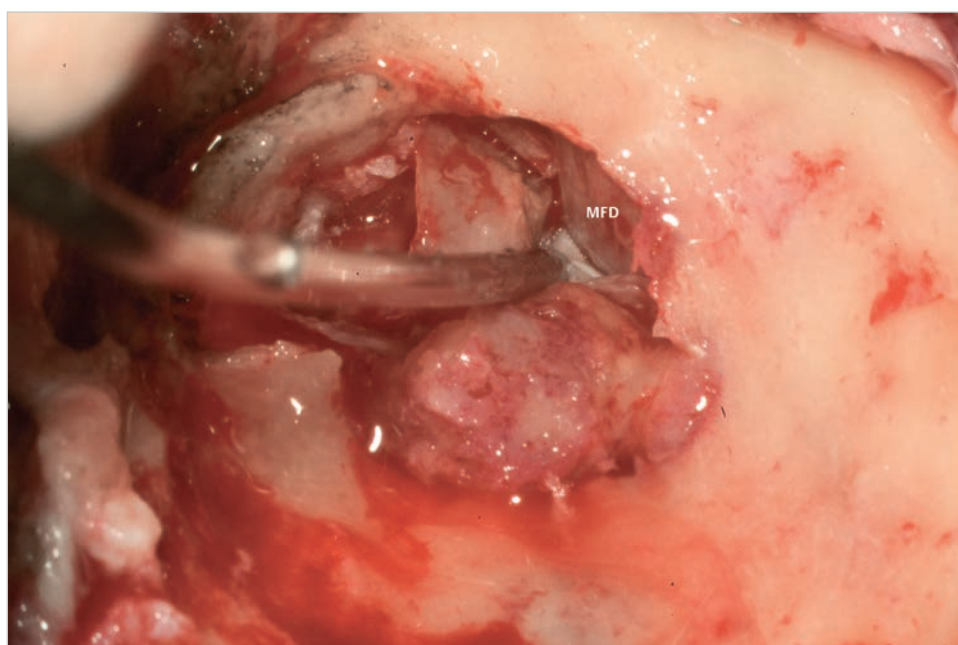


Fig. 11.126 After debulking debris of cholesteatoma, the thin matrix is carefully detached from the middle fossa dura to verify absence of meningoencephalocele. MFD, middle fossa dura.

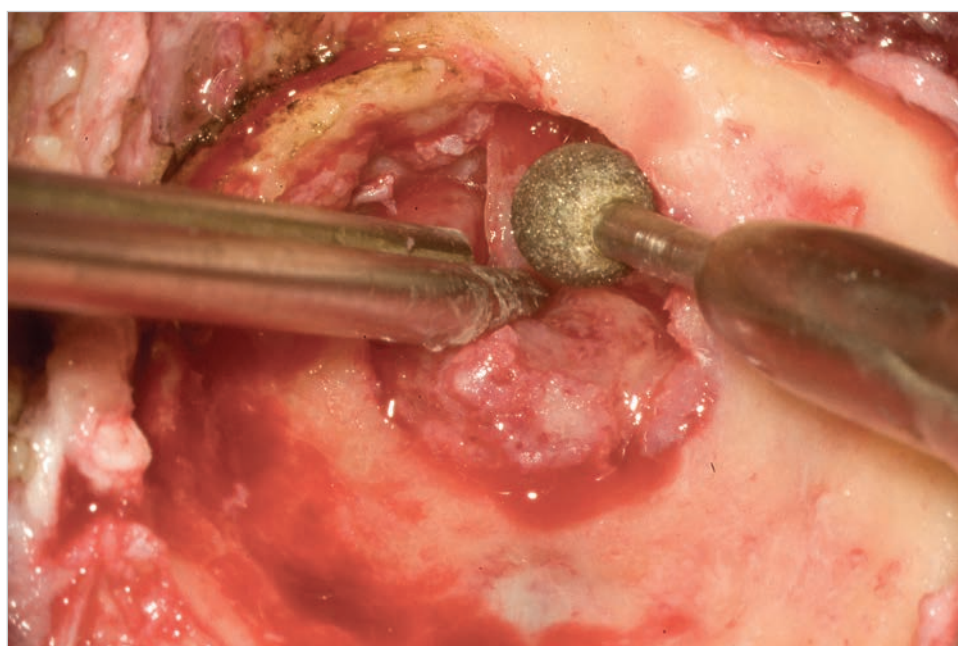


Fig. 11.127 After locating the dura, the sharp edges in the cavity are removed to obtain better access to the middle ear. A large diamond burr is used not to damage the dura.

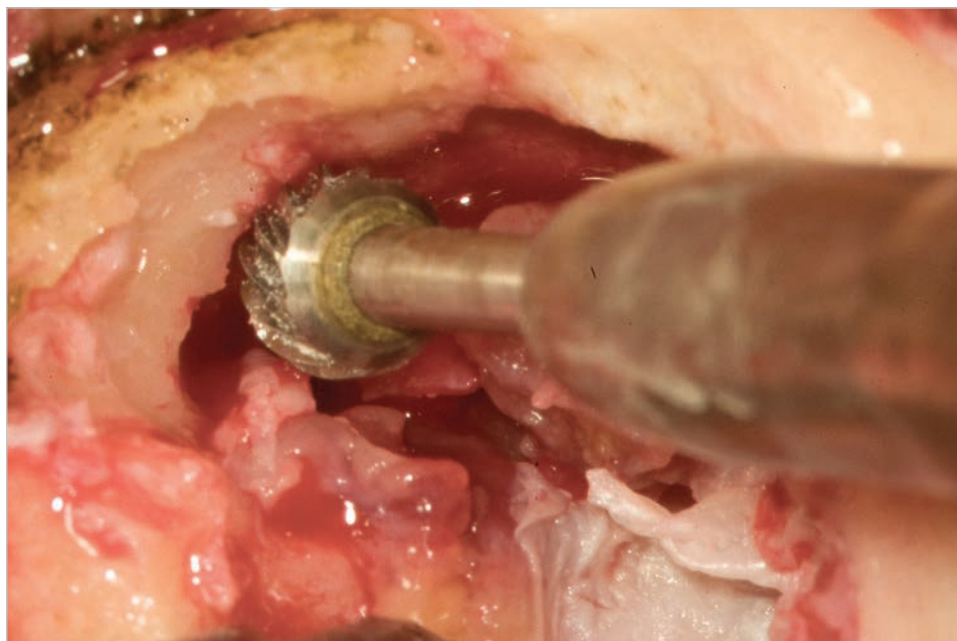


Fig. 11.128 The anterior and inferior meatal wall is calibrated with a large cutting burr.

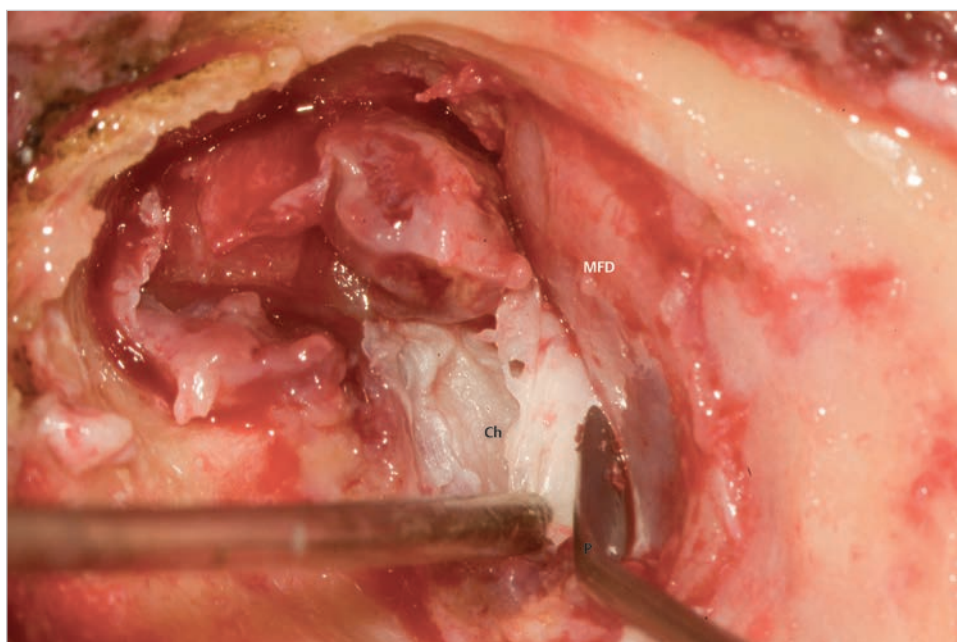


Fig. 11.129 The matrix is carefully dissected from the thin middle fossa dura. Ch, cholesteatoma; MFD, middle fossa dura.

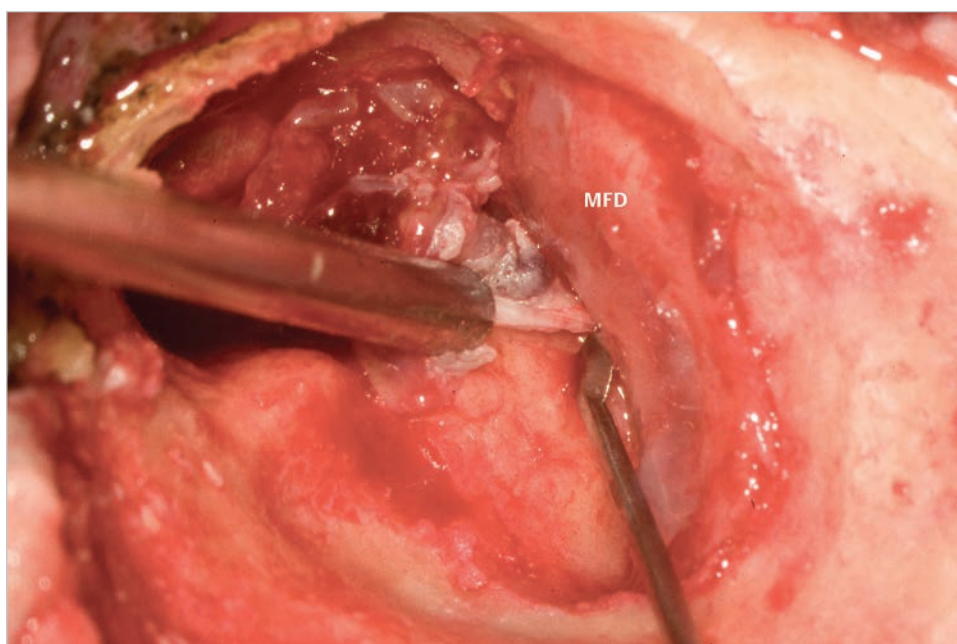


Fig. 11.130 Dissection of matrix usually becomes relatively difficult at the boundary between the dura and the bone. MFD, middle fossa dura.

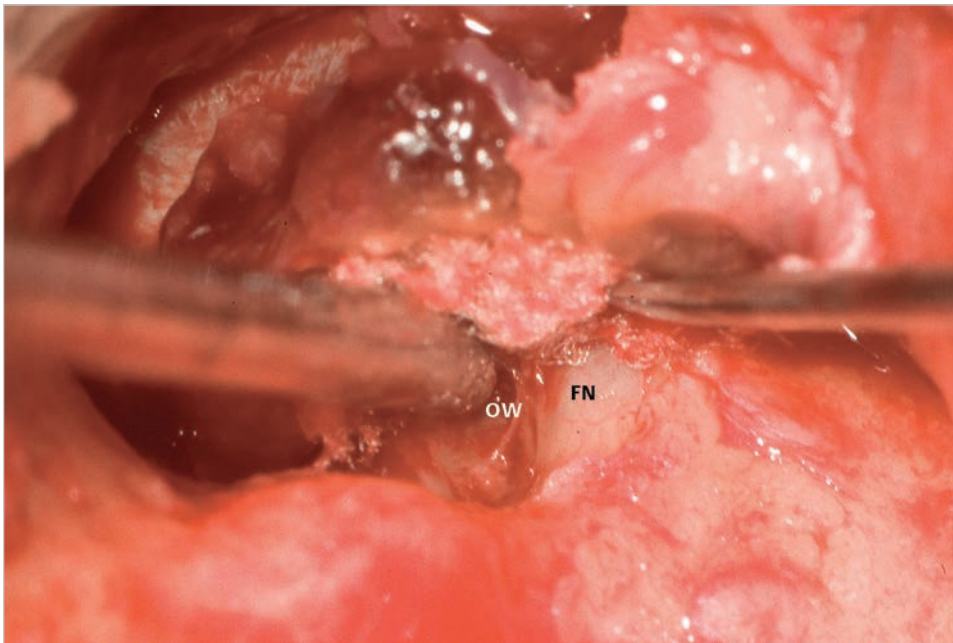


Fig. 11.131 The inflamed skin and granulation tissue are dissected from the exposed facial nerve with the help of cottonoid. FN, facial nerve; OW, oval window.

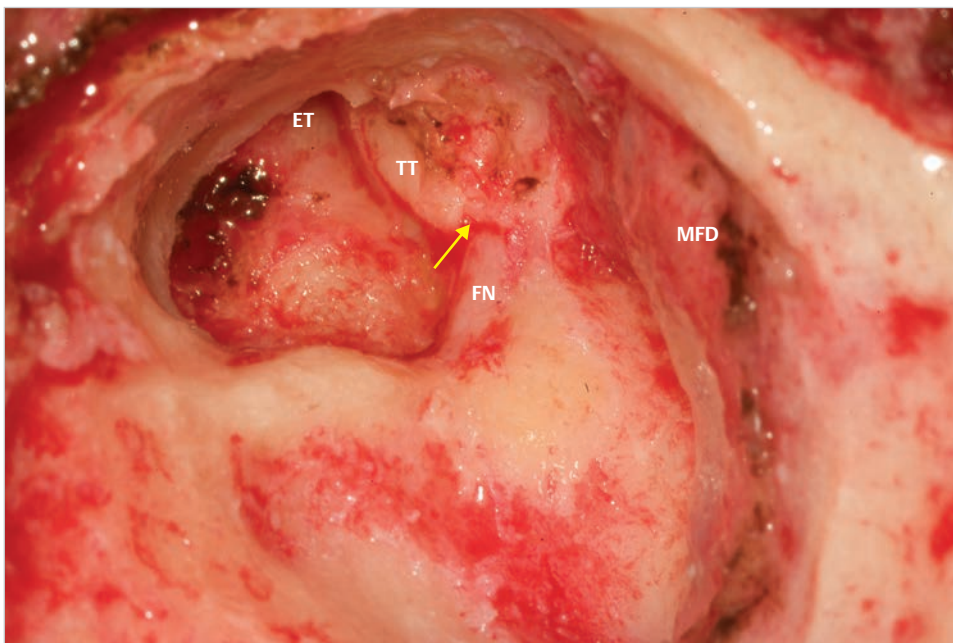


Fig. 11.132 The final shape of the cavity is shown. The semicanal of the tensor tympani muscle coursing the superomedial aspect of the eustachian tube to reach the cochleariform process (arrow) is clearly seen. ET, eustachian tube; FN, facial nerve; MFD, middle fossa dura; TT, tensor tympani.

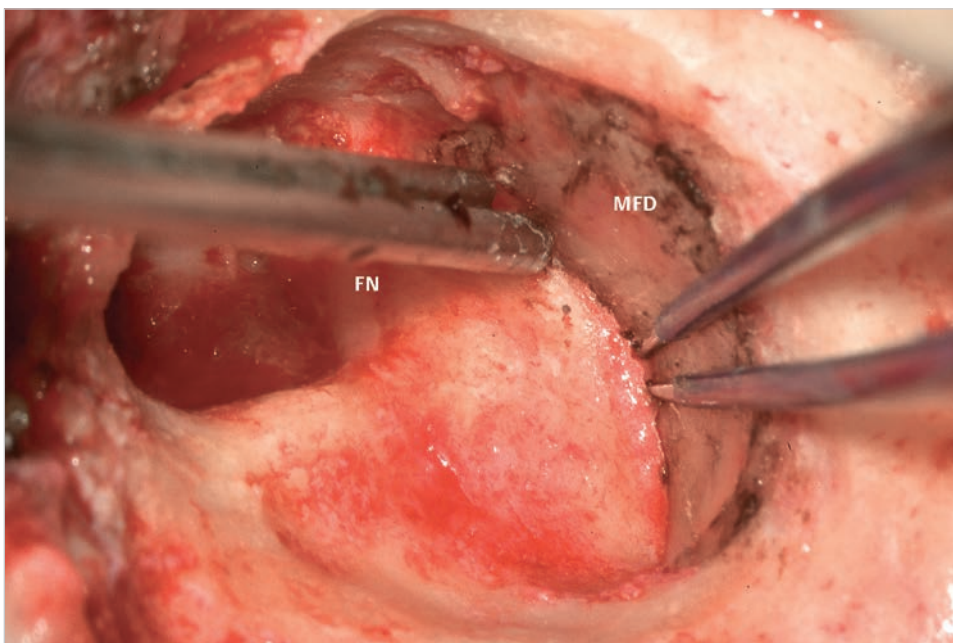


Fig. 11.133 The middle fossa dura extensively exposed in the tegmen is shown. Suspicious area for residual matrix should be coagulated with bipolar. Use of monopolar coagulation is strictly prohibited in this procedure to avoid creating a hole. FN, facial nerve; MFD, middle fossa dura.

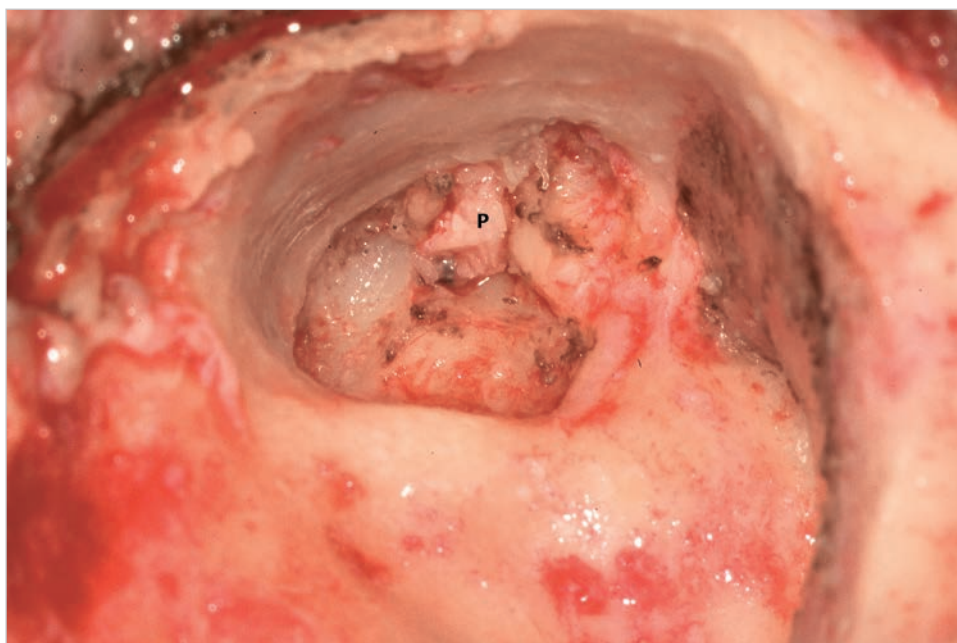


Fig. 11.134 The eustachian tube is closed with periosteum, and the cavity is packed with abdominal fat. P, periosteum.

Case 11.12 (Right Ear)

See ►Fig. 11.135, ►Fig. 11.136, ►Fig. 11.137, ►Fig. 11.138, ►Fig. 11.139, ►Fig. 11.140.

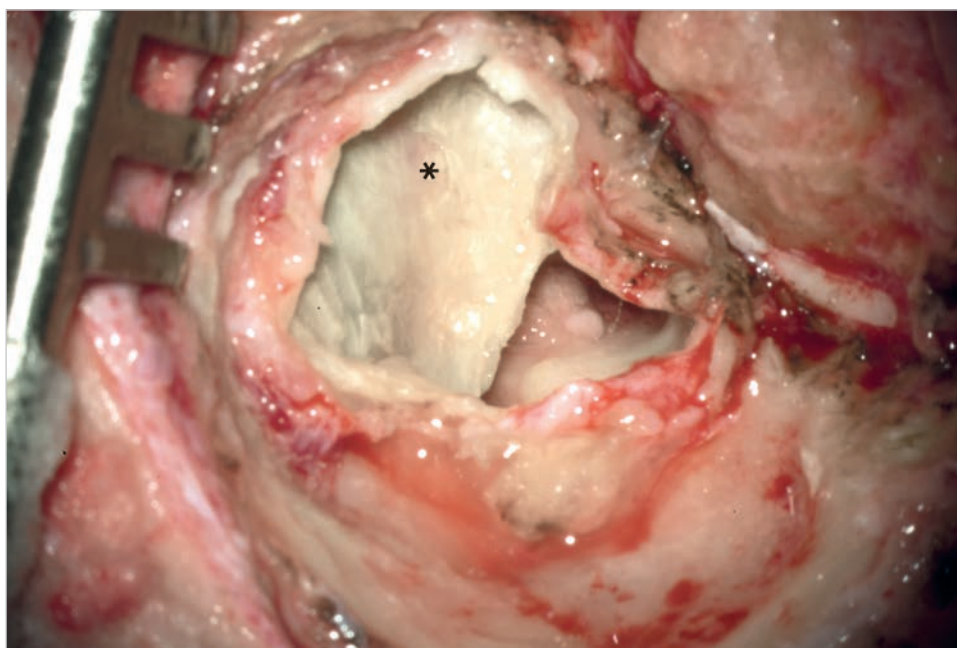


Fig. 11.135 A case of draining cavity with extensive exposure of middle fossa dura (asterisk) is shown. Since the cavity is huge and severely inflamed, there is no alternative but to close the external auditory canal to stop otorrhea.

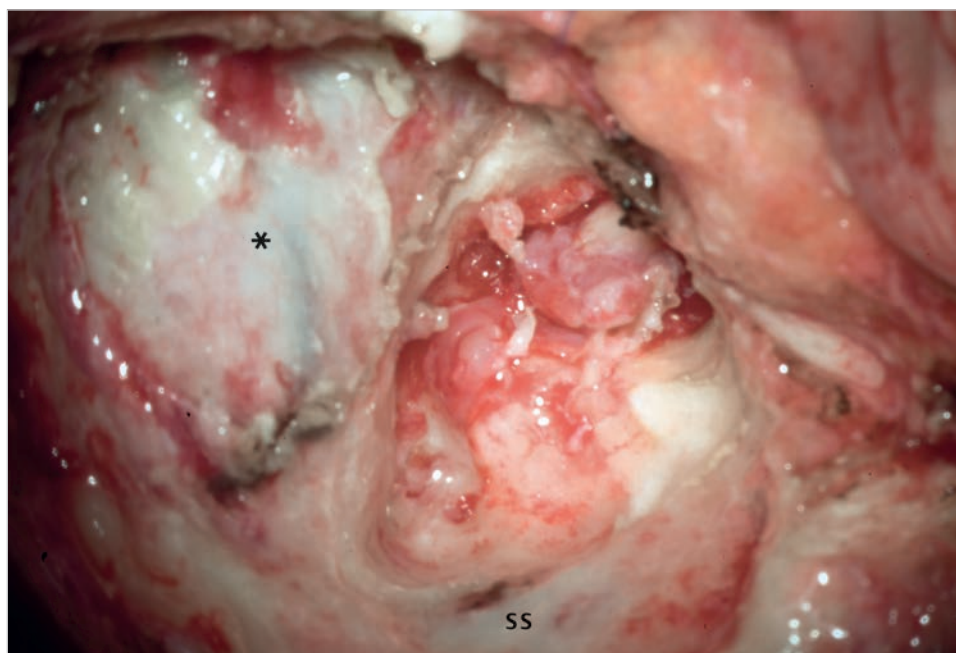


Fig. 11.136 The cholesteatoma extends superiorly to expose widely the lateral face of the middle fossa dura (*asterisk*). The tympanic membrane is completely adherent to the medial wall, and no space is found in the tympanic cavity. Since there is a possibility to open the dura, removal of the matrix from the dura should be left until the final moment to avoid intracranial infection. SS, sigmoid sinus.

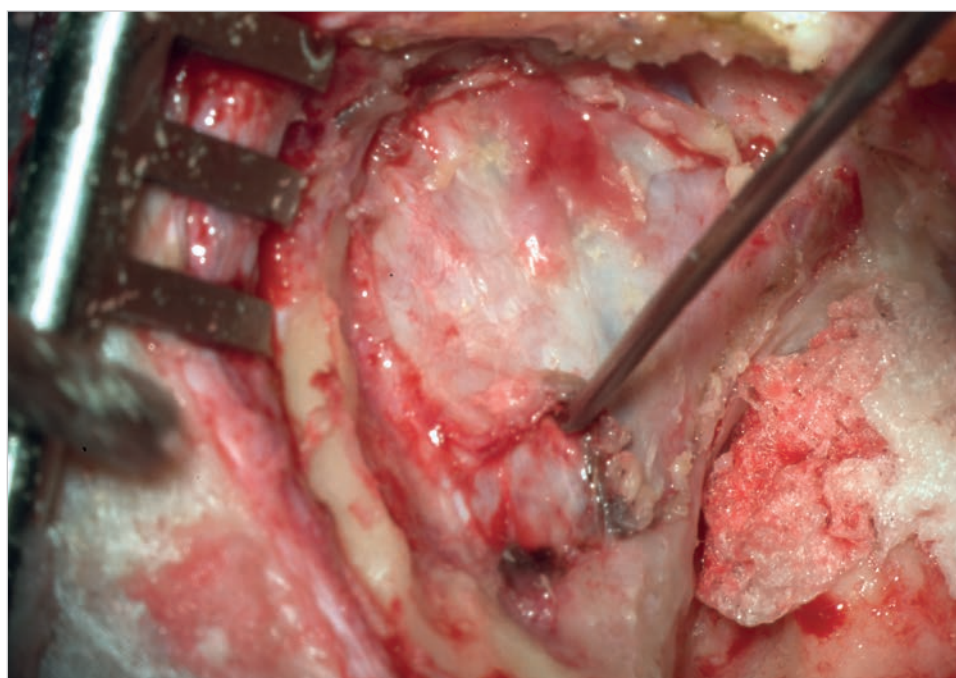


Fig. 11.137 Dissection of the cholesteatoma matrix from the dura is conducted with a small raspator. The tympanic cavity is packed with small cottonoids to achieve complete hemostasis.

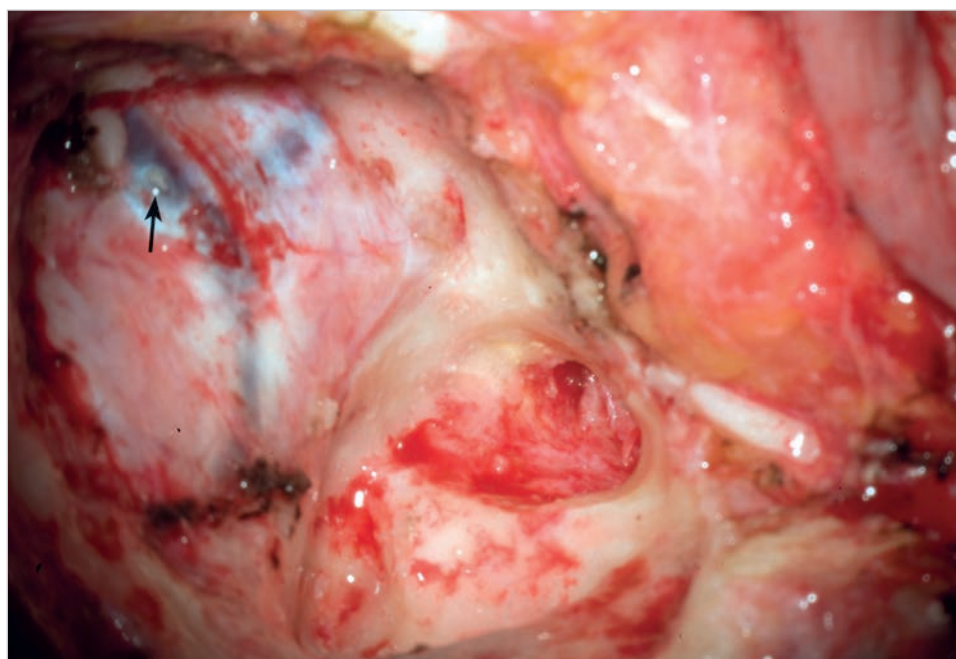


Fig. 11.138 Removal of cholesteatoma matrix from the middle fossa dura is completed. Meningeal veins are seen through the dura. Cerebrospinal fluid leaking out from a small tear created during the dissection is indicated by the arrow. If there is any suspicion of matrix being left on the dura, the area should be coagulated with bipolar coagulator.

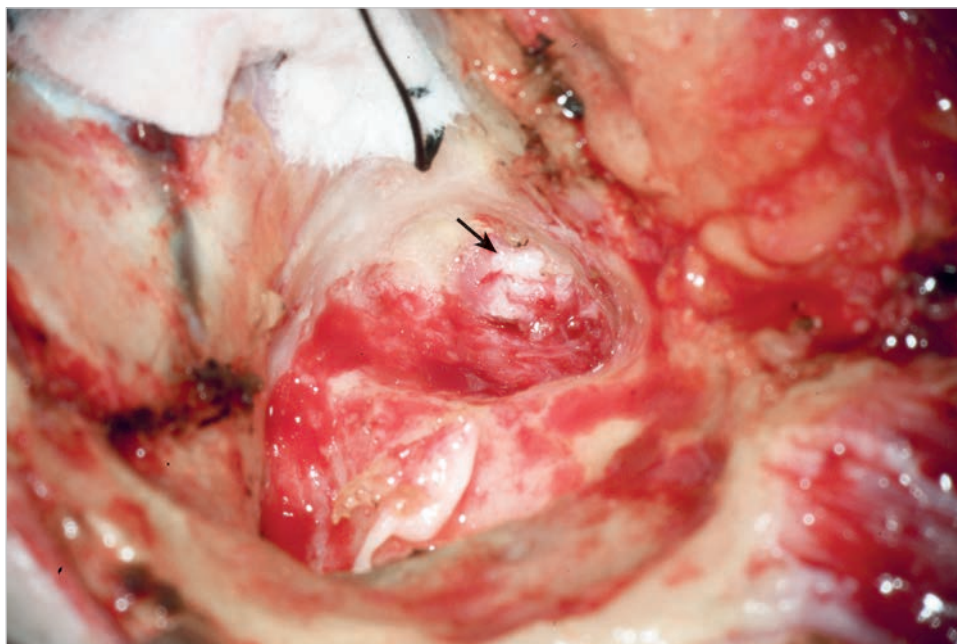


Fig. 11.139 To avoid postoperative cerebrospinal fluid leak, the eustachian tube is obliterated with pieces of periosteum (*arrow*).

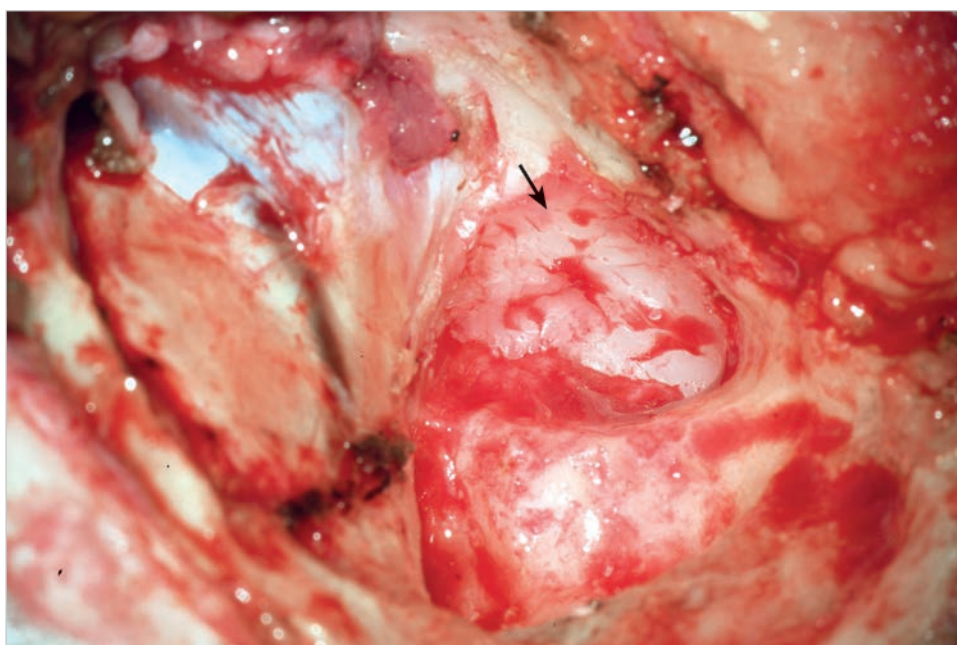


Fig. 11.140 The eustachian tube is further obliterated with bone wax (*arrow*), and the cavity is packed with abdominal fat.

Case 11.13 (Right Ear)

See ►Fig. 11.141, ►Fig. 11.142, ►Fig. 11.143, ►Fig. 11.144, ►Fig. 11.145, ►Fig. 11.146.

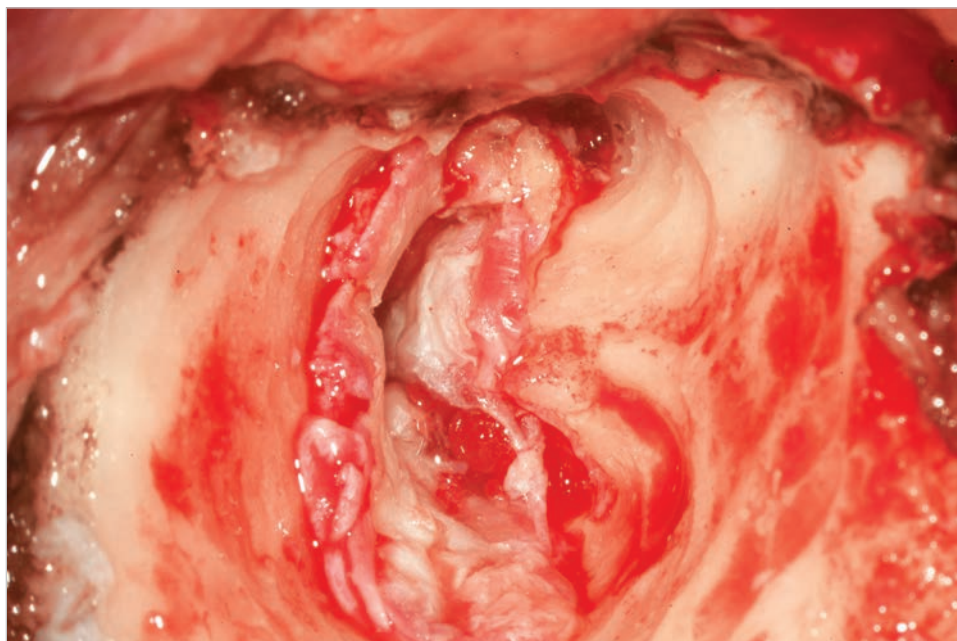


Fig. 11.141 Recurrent cholesteatoma in canal wall down cavity with nonserviceable hearing complicated with meningoencephalic herniation. Severely inflamed cavity with granulation tissue and accumulation of debris is shown.

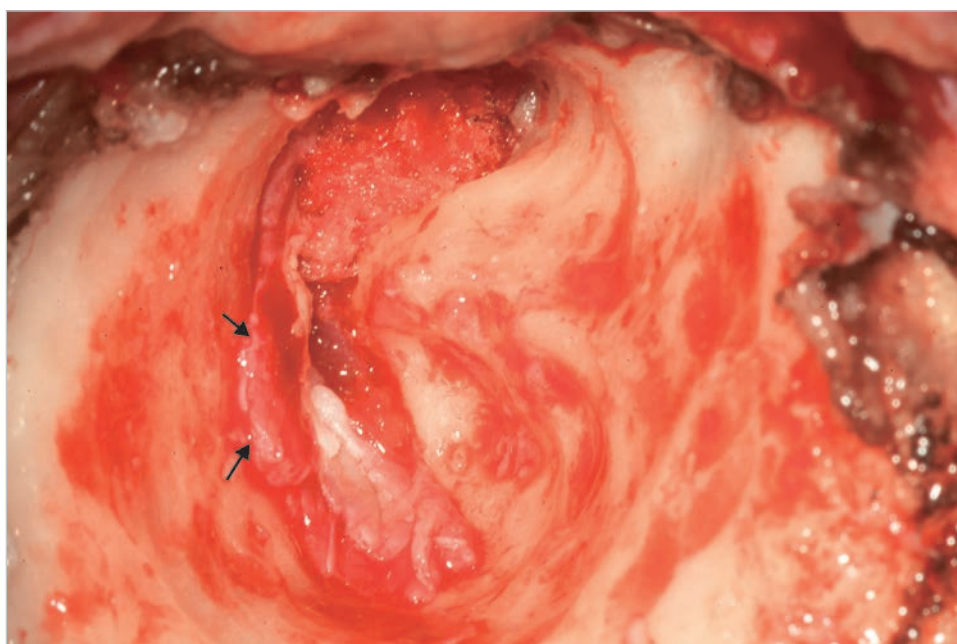


Fig. 11.142 The lateral part of the inflamed skin is resected to gain access to the more medial portion. A meningoencephalic herniation protruding from the tegmen of the mastoid is identified (*arrows*) under the inflamed skin. The tympanic cavity is temporally packed with cottonoids.



Fig. 11.143 Meningoencephalic herniation protruding from the tegmen of the mastoid (*arrows*) is shown.

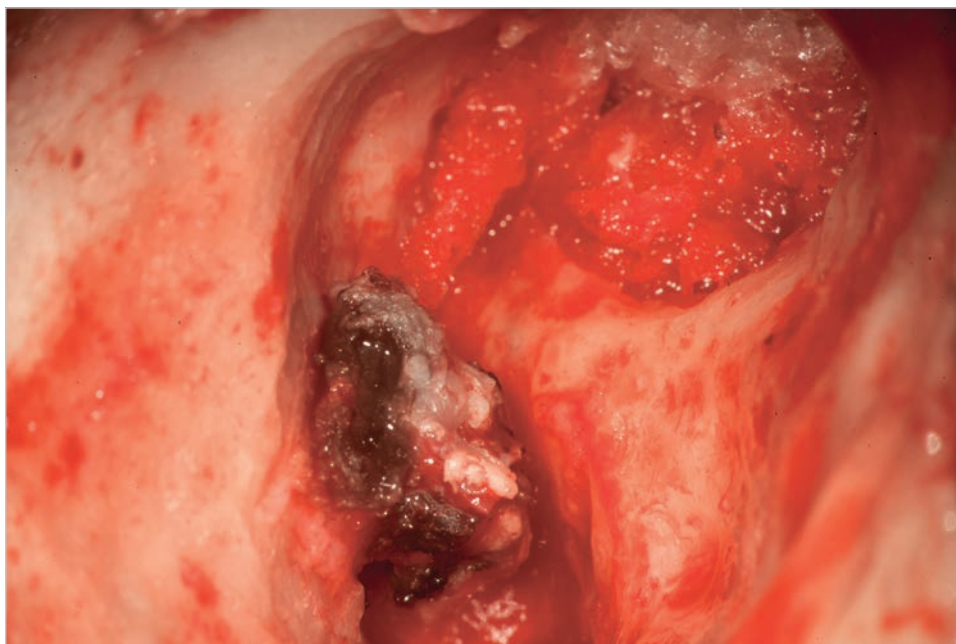


Fig. 11.144 The herniated tissue partially covered with skin is coagulated with bipolar. The procedure shrinks the herniated tissue.

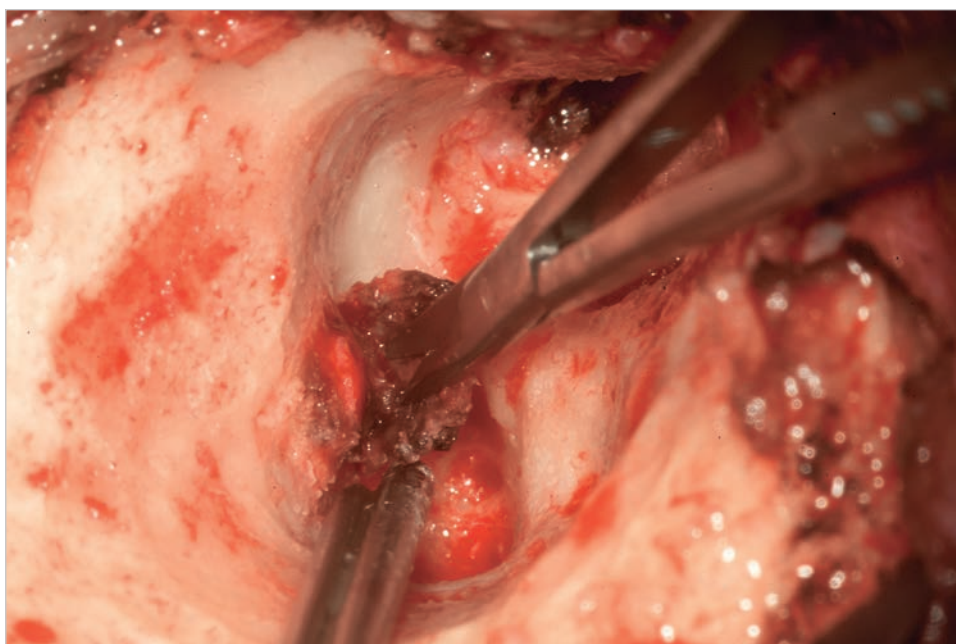


Fig. 11.145 The coagulated tissue is resected with scissors.

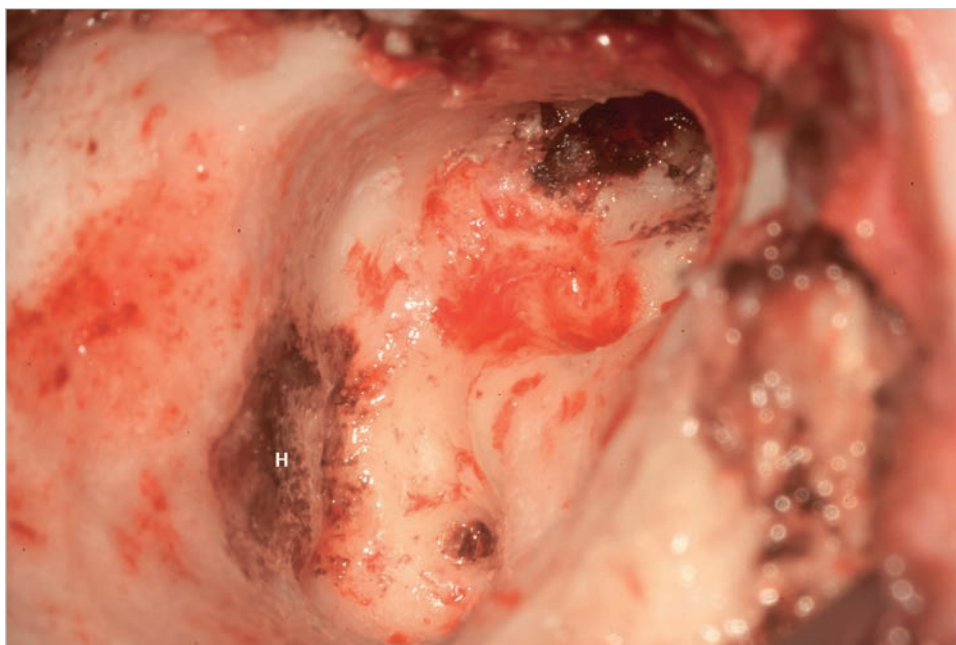


Fig. 11.146 All skin and pathologic tissue including meningoencephalic herniation are removed from the cavity. The eustachian tube is obliterated with pieces of periosteum, and the cavity is packed with abdominal fat. H, meningoencephalic herniation.

Case 11.14 (Right Ear)

See ▶Fig. 11.147, ▶Fig. 11.148, ▶Fig. 11.149, ▶Fig. 11.150, ▶Fig. 11.151, ▶Fig. 11.152, ▶Fig. 11.153, ▶Fig. 11.154, ▶Fig. 11.155, ▶Fig. 11.156, ▶Fig. 11.157, ▶Fig. 11.158, ▶Fig. 11.159, ▶Fig. 11.160.

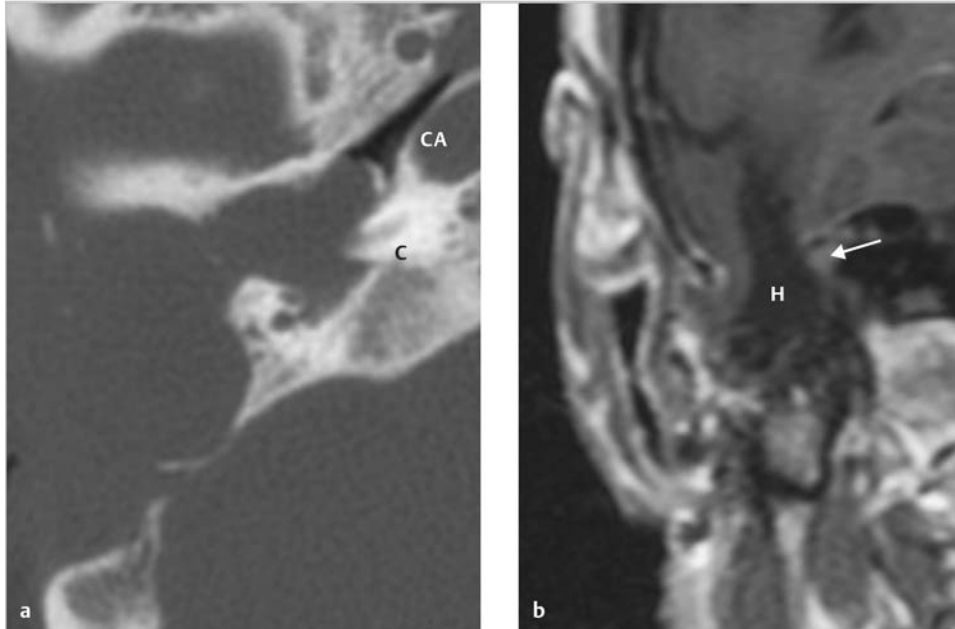


Fig. 11.147 The patient underwent middle ear surgery, which was followed by progressive hearing loss complicated by intractable otorrhea. Otoscopic examination showed a pinkish pulsating mass in the external auditory canal. Radiologic examination revealed meningoencephalic herniation in the middle ear. In the axial CT (a), a large soft tissue with smooth border is seen. The coronal MRI (b) shows herniation of the brain tissue into the middle ear from the defect in the middle fossa plate (arrow). C, cochlea; CA, carotid artery; H, herniated tissue.

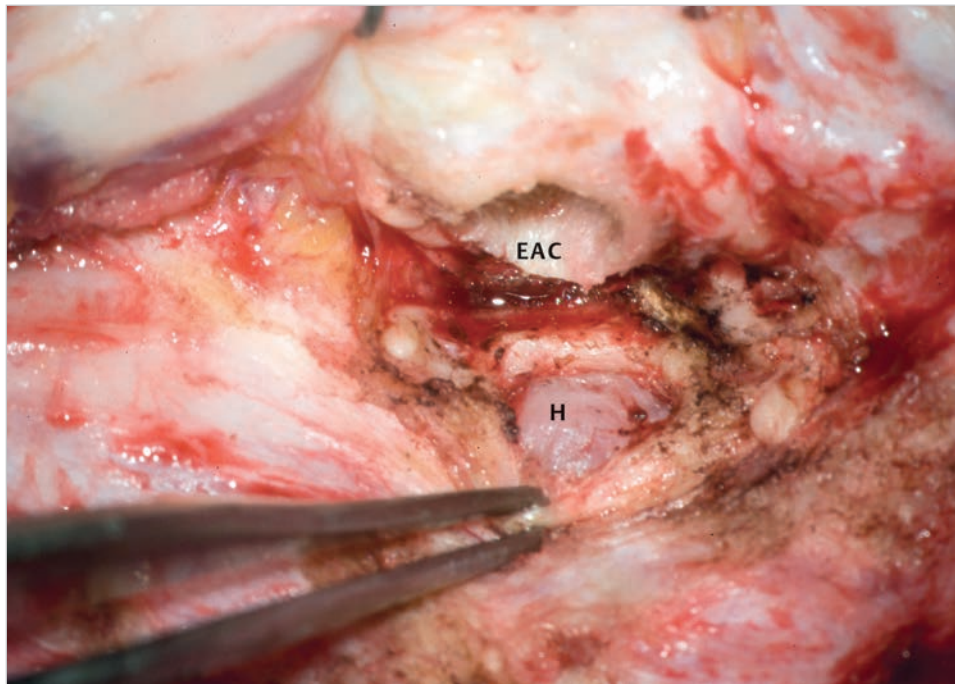


Fig. 11.148 A retroauricular incision is made, and the musculoepiosteal layer covering the area of the mastoid was exposed. A circumferential cut at this level exposed meningoencephalic herniation in the external auditory canal. EAC, external auditory canal; H, meningoencephalic herniation.

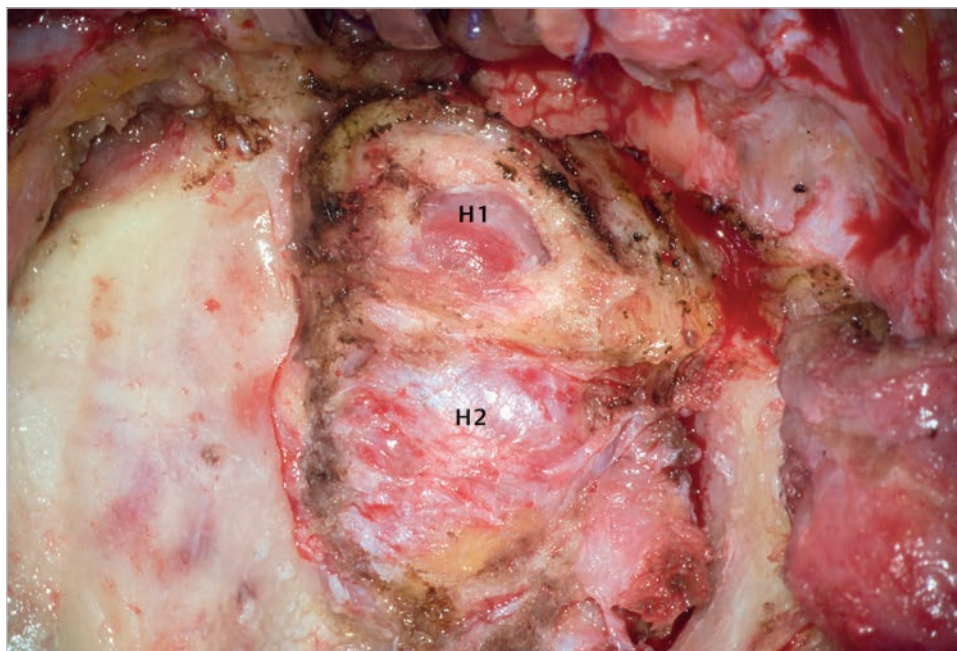


Fig. 11.149 Blind-sac closure of the external auditory canal is conducted, and the musculo-periosteal layer is elevated to expose the large herniated tissue occupying the mastoid cavity. H1, herniation in the external auditory canal; H2, herniation in the mastoid.

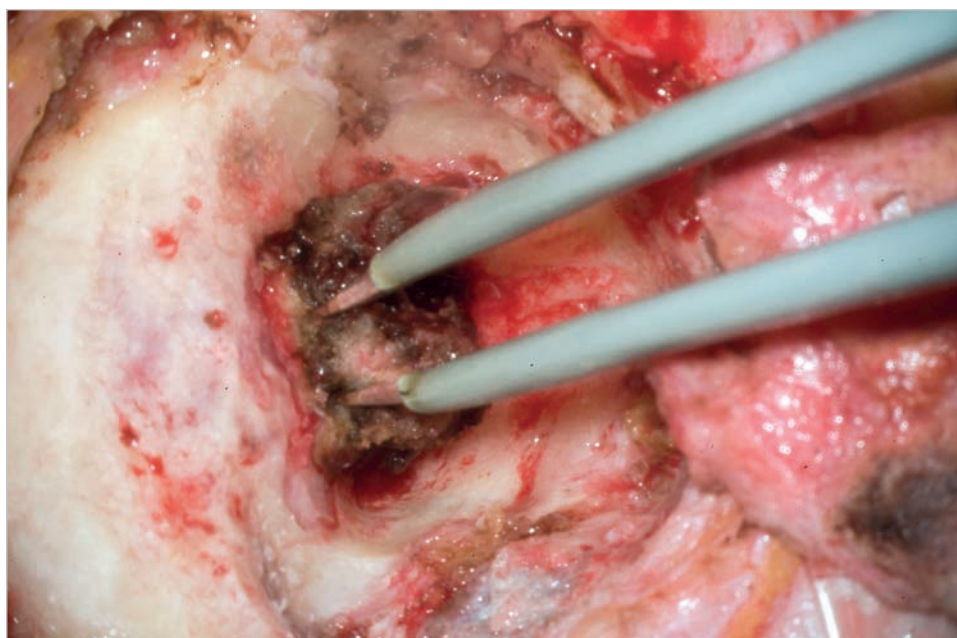


Fig. 11.150 The herniation is coagulated with the bipolar coagulator. The procedure shrinks herniated tissue and facilitates dissection from the surrounding structures.



Fig. 11.151 The coagulated tissue is cut with scissors in piecemeal fashion.

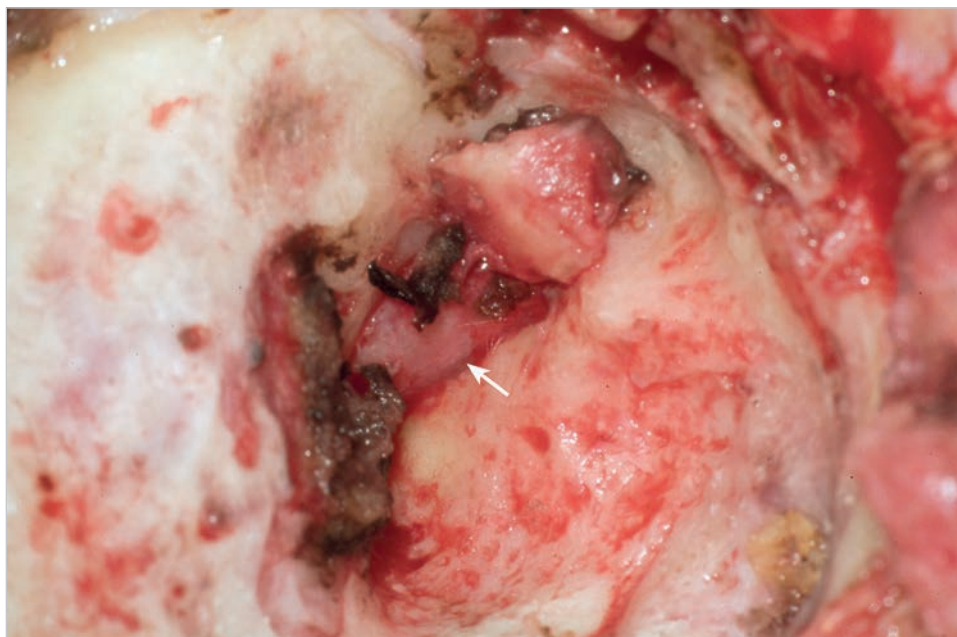


Fig. 11.152 Another herniated tissue is seen medially in the external auditory canal (*arrow*).



Fig. 11.153 The coagulated tissue is cut with scissors in piecemeal fashion.

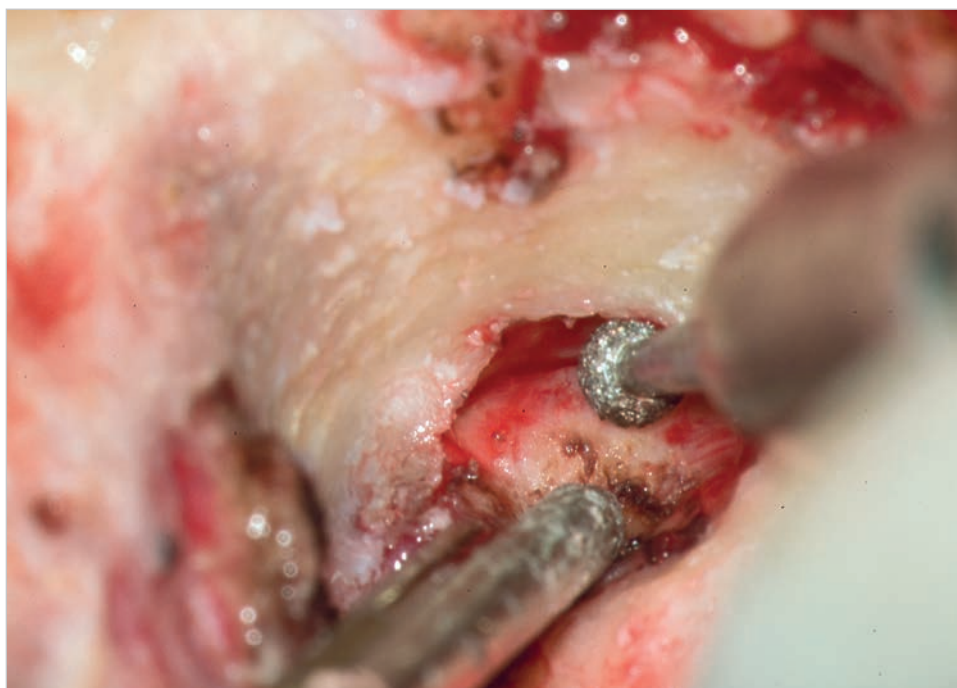


Fig. 11.154 Canaloplasty is carried out to sufficiently visualize the herniation in the meatus.

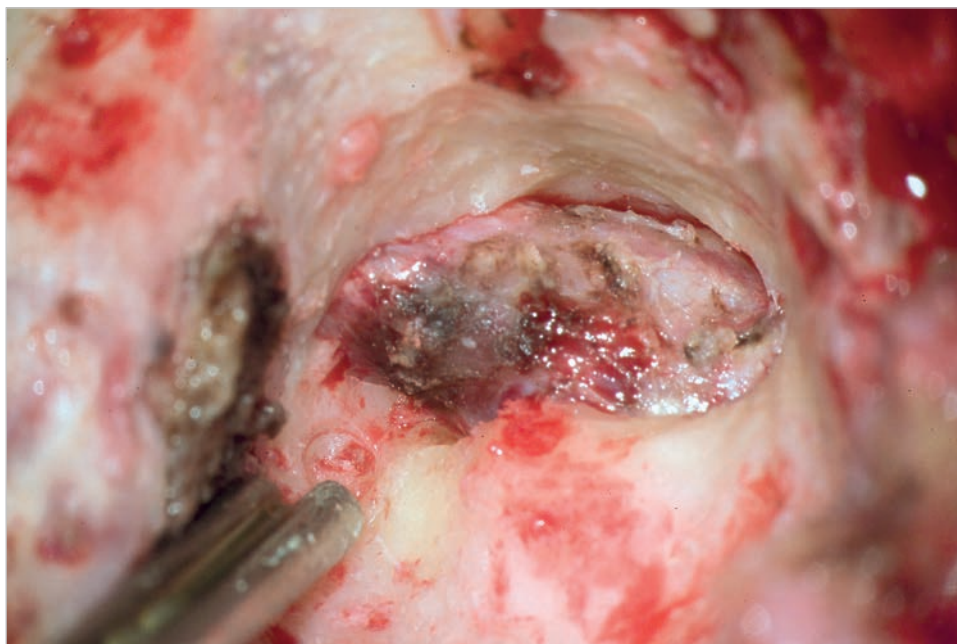


Fig. 11.155 The herniated tissue occupying the tympanic cavity is exposed.

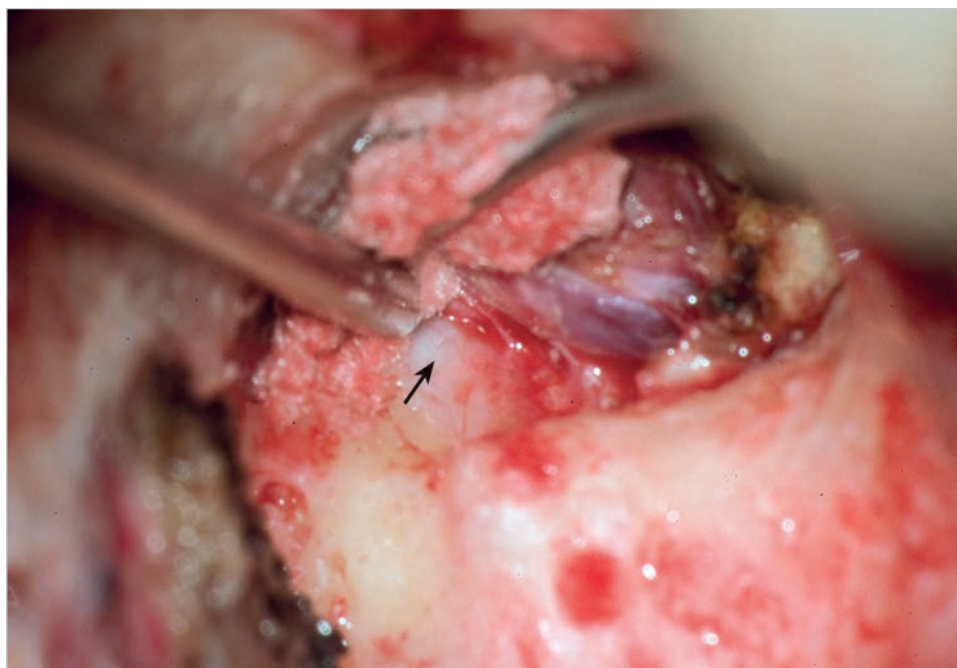


Fig. 11.156 The herniated tissue is dissected from the tympanic segment of the facial nerve (*arrow*) using a cottonoid. Note that the nerve is extensively exposed in this area.



Fig. 11.157 Medially to the herniation, entrapped skin has formed cholesteatoma (*arrow*).

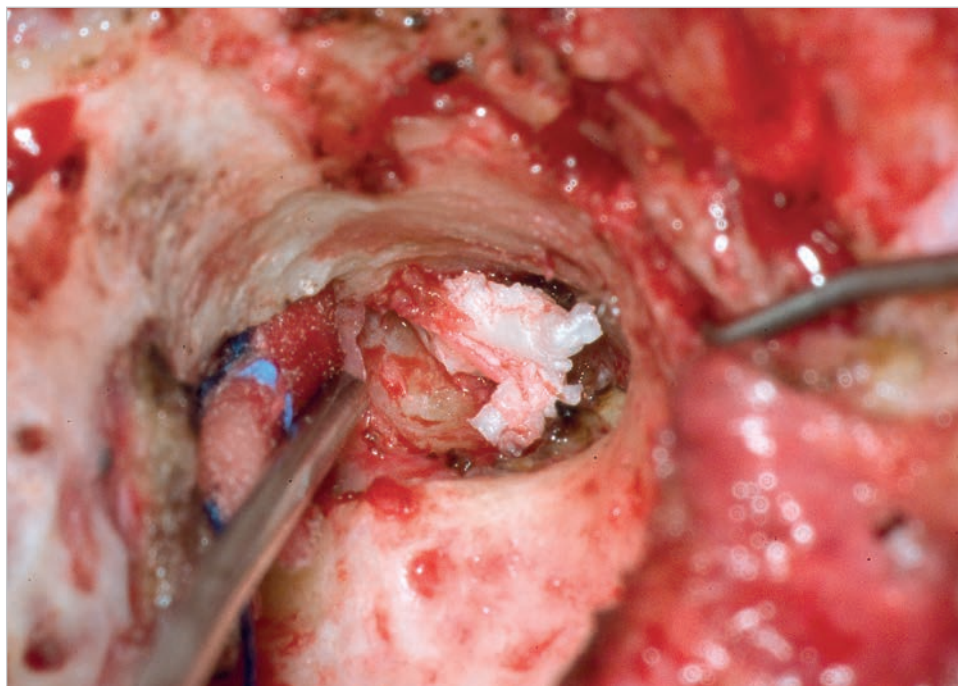


Fig. 11.158 The cholesteatoma is dissected from the tympanic cavity.

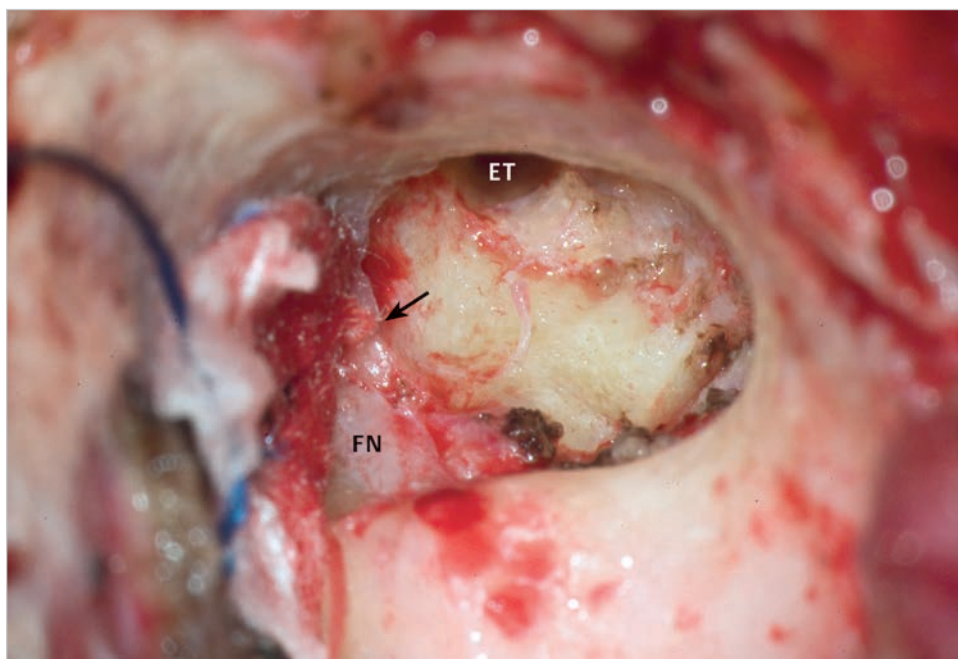


Fig. 11.159 All the skin and herniated tissue have been eradicated from the middle ear. The exposed facial nerve is seen running just superiorly to the cochleariform process (*arrow*). ET, eustachian tube; FN, facial nerve.

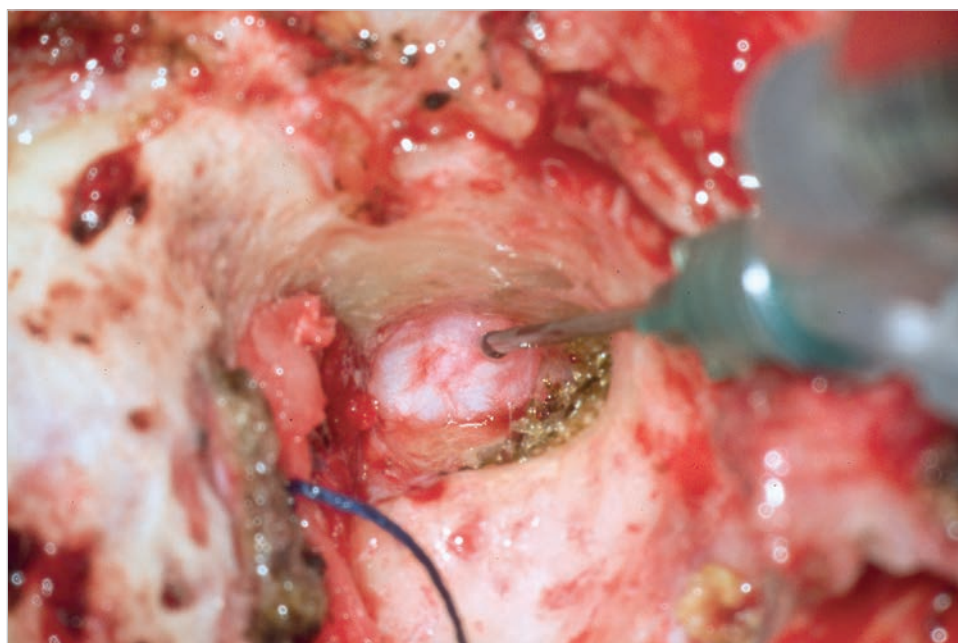


Fig. 11.160 The eustachian tube is obliterated with pieces of periosteum. Fibrin glue is applied to ensure closure in this case. The cavity is packed with abdominal fat.

Case 11.15 (Left Ear)

See ▶Fig. 11.161, ▶Fig. 11.162, ▶Fig. 11.163, ▶Fig. 11.164, ▶Fig. 11.165, ▶Fig. 11.166, ▶Fig. 11.167, ▶Fig. 11.168, ▶Fig. 11.169, ▶Fig. 11.170.

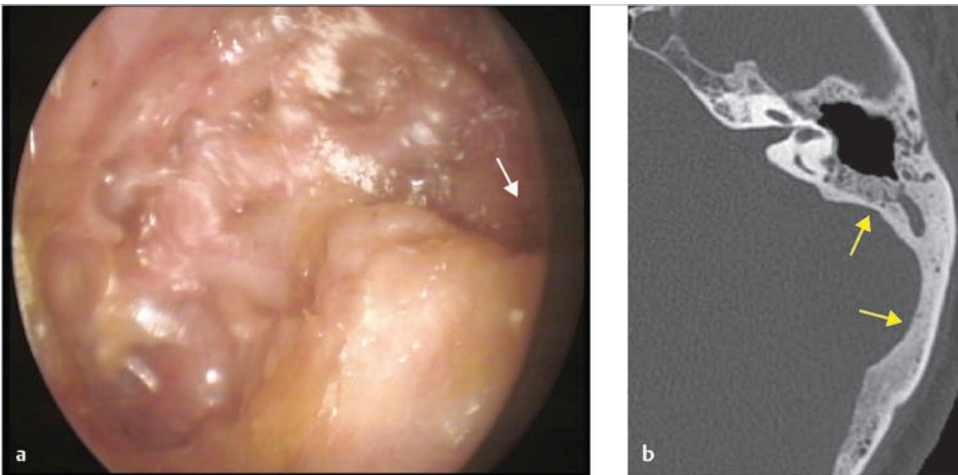


Fig. 11.161 The patient underwent cholesteatoma surgery elsewhere followed by continuous otorrhea and visited our office with dull pain in retroauricular region. Otoscopic examination showed wet inflamed cavity especially in the area of mastoid tip (*white arrow*) with the high facial ridge (*a*). The axial CT (*b*) shows round-shaped bone erosion in the posterior face of the temporal bone (*yellow arrows*).

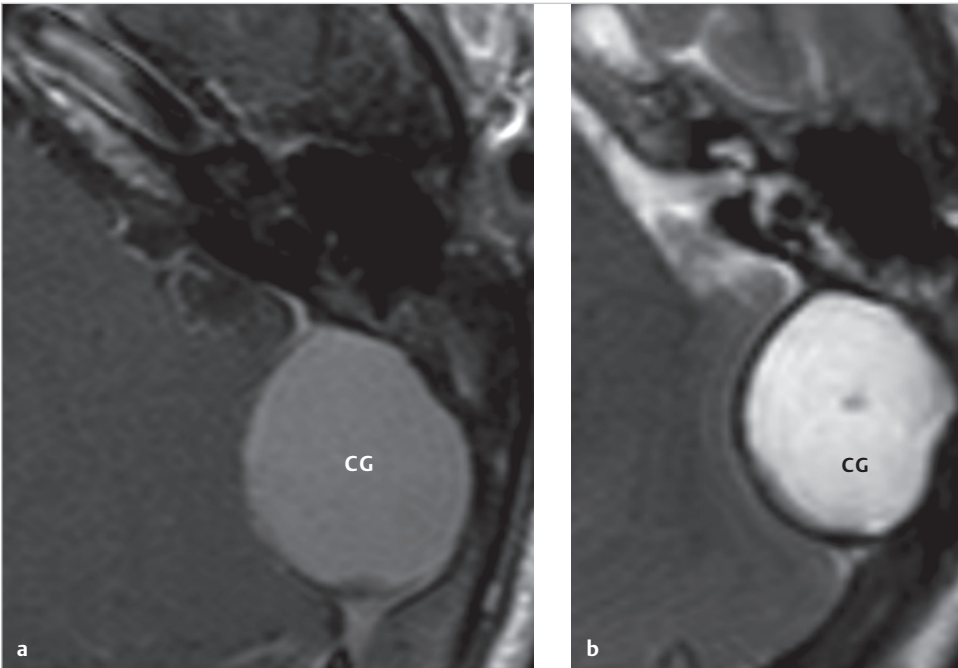


Fig. 11.162 Further radiologic examination using MRI showed large round-shaped mass beneath the mastoid, pushing the posterior fossa dura to compress the cerebellum. The lesion shows high signal in T1 (*a*), and very high in T2 (*b*) corresponding to cholesterol granuloma. CG, cholesterol granuloma.

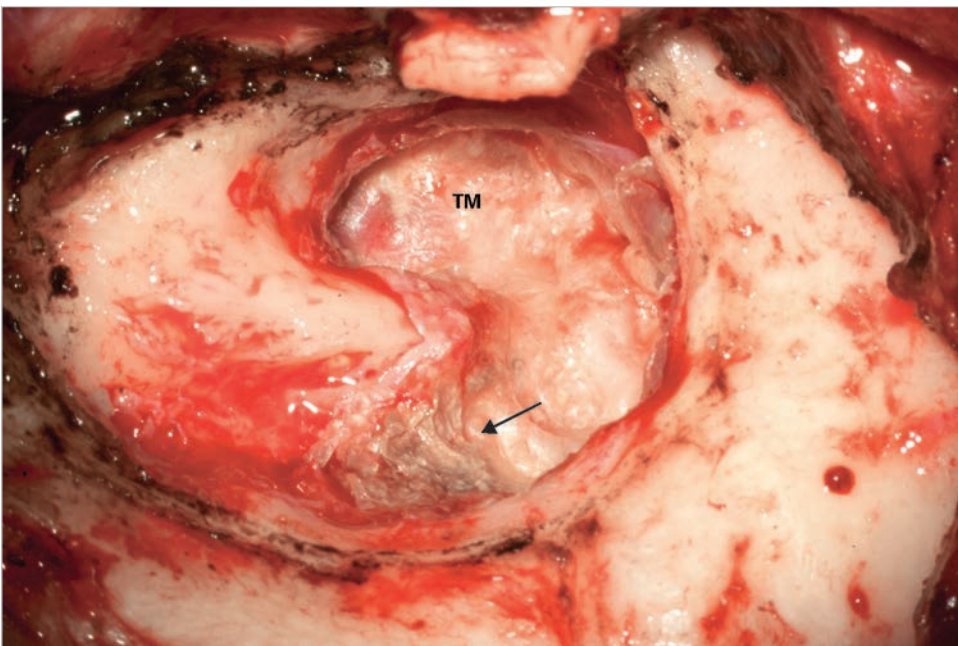


Fig. 11.163 Via retroauricular incision, the cavity is opened. The tympanic membrane is completely adherent to the medial wall. Wet cerumen is accumulated in the mastoid tip (*arrow*). TM, tympanic membrane.

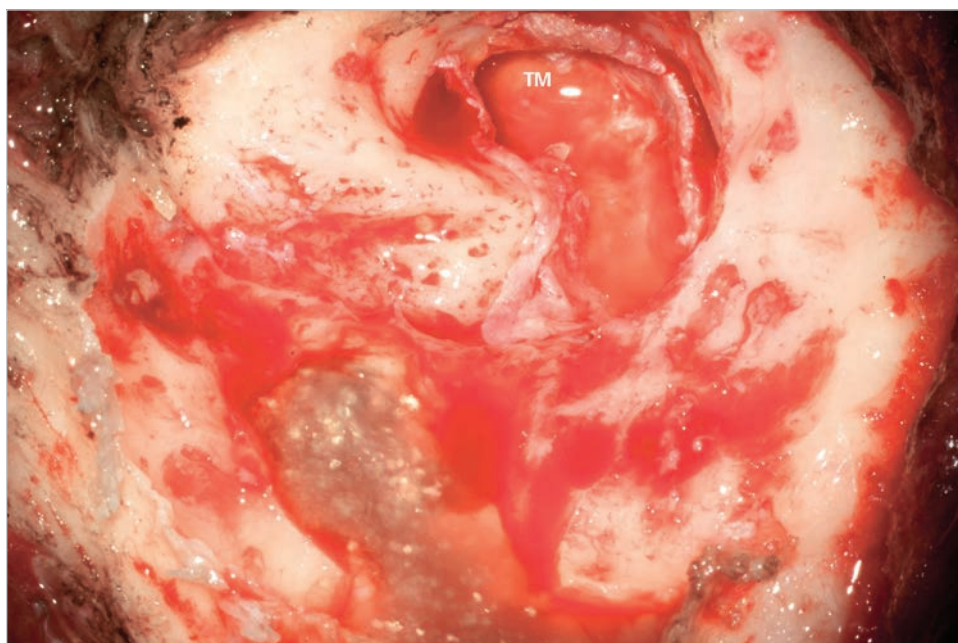


Fig. 11.164 Dissection of cholesteatoma from the area of the mastoid tip opened a bursiform structure containing brownish fluid with cholesterol crystals. TM, tympanic membrane.

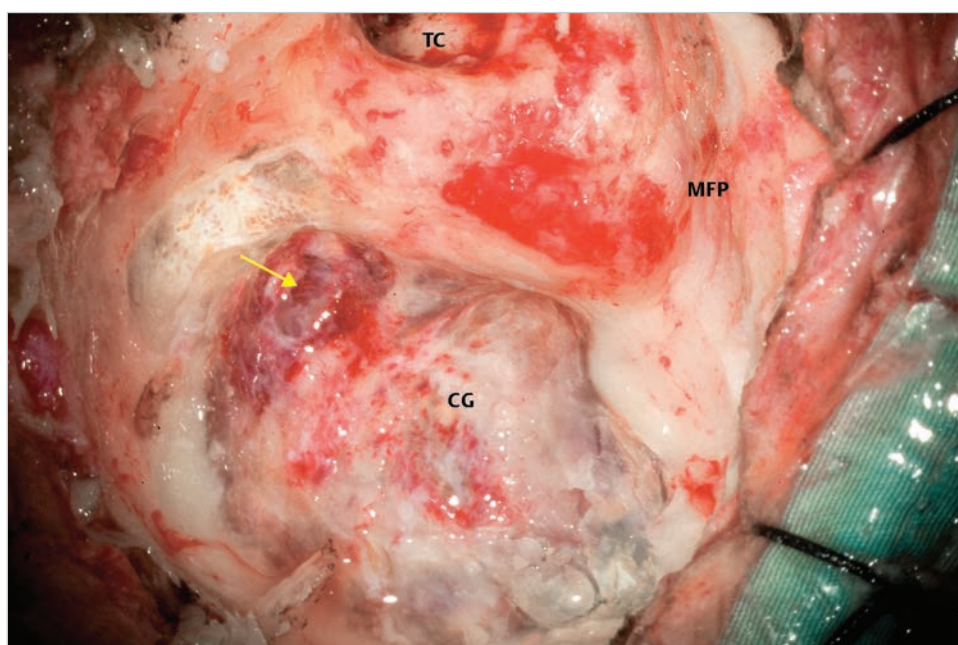


Fig. 11.165 The skin covering the cavity is totally removed, and the cavity is rounded. The cortical bone covering the posterior fossa is removed to expose very large cholesterol granuloma formed far from the tympanic cavity. The location of an opening of the cholesterol granuloma (arrow) corresponds to the wet mastoid tip. CG, cholesterol granuloma; MFP, middle fossa plate; TC, tympanic cavity.

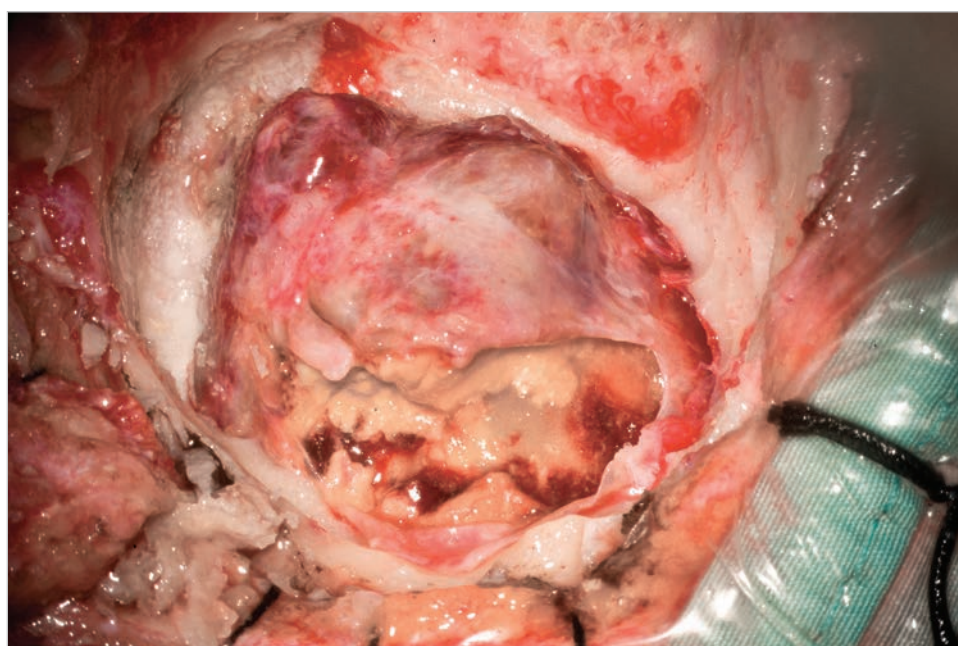


Fig. 11.166 The lateral wall of cholesterol granuloma opened to expose yellowish amorphous matter filling the granuloma.

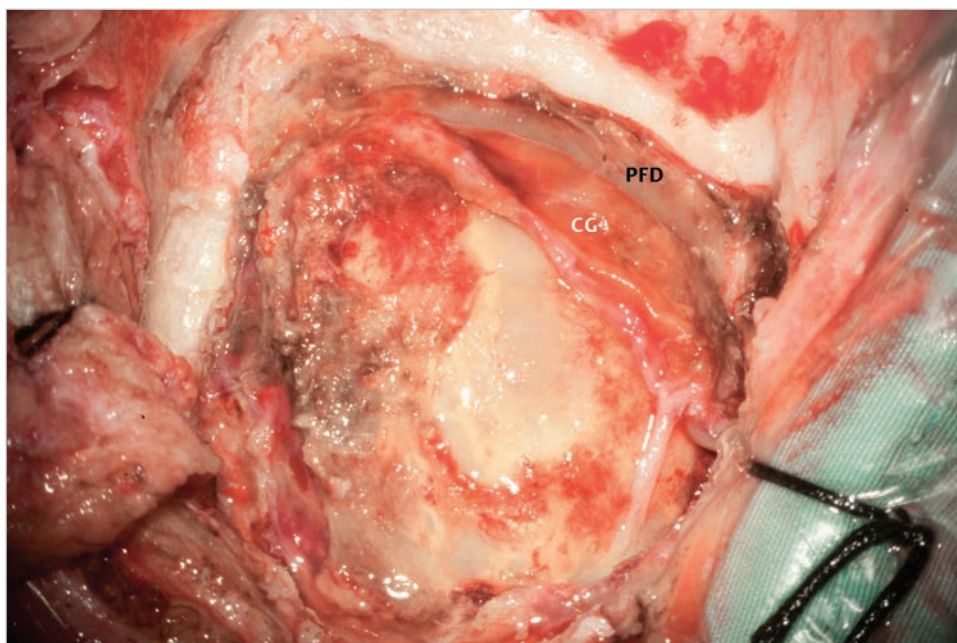


Fig. 11.167 Contents of the cholesterol granuloma is evacuated. The medial wall of it is started to be dissected from the posterior fossa dura. CG, cholesterol granuloma; PFD, posterior fossa dura.

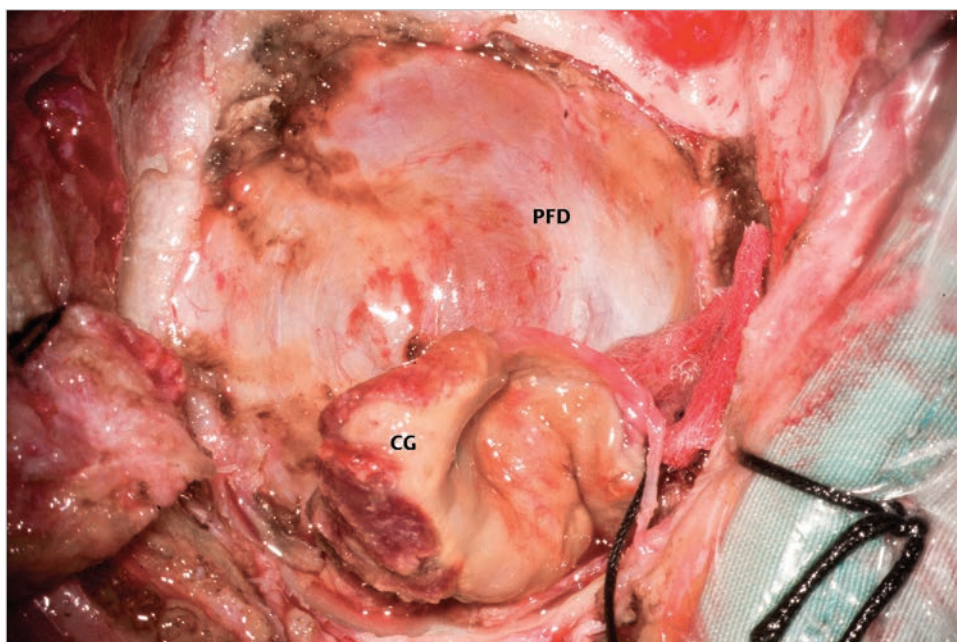


Fig. 11.168 The majority of the cholesterol granuloma is detached from the dura. Note that the cleavage between the dura and the granuloma is clear. CG, cholesterol granuloma; PFD, posterior fossa dura.



Fig. 11.169 The cholesterol granuloma is completely removed, and the final shape of the cavity is seen. A huge space is present posteriorly to the cavity. To avoid postoperative problems, the eustachian tube is closed with perichondrium, and the cavity is obliterated with abdominal fat. CG, cholesterol granuloma; PFD, posterior fossa dura.

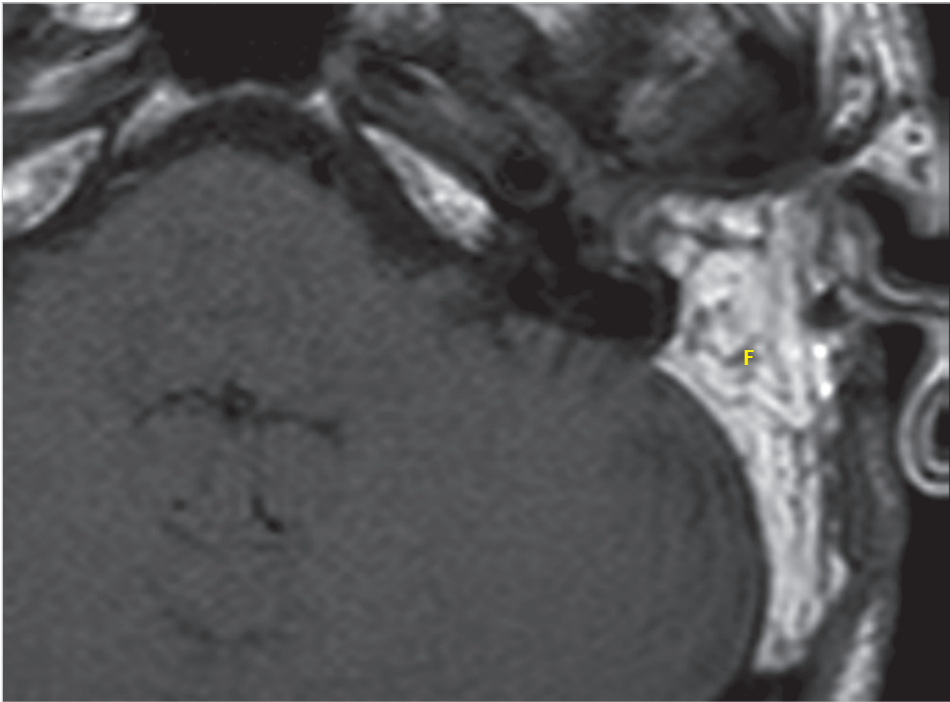


Fig. 11.170 The postoperative MRI shows release of cerebellar compression with appropriate packing of the cavity with abdominal fat. F, abdominal fat.

11.2 Hints and Pitfalls

- The blind-sac closure of the external auditory canal is easier to perform when the transection of the skin and cartilage is carried out more laterally. The skin is thicker at this site, making dissection easier.
- Infection of the fat in the cavity is difficult to manage with conservative treatment, necessitating revision surgery.
- The microscope is used to dissect the meatal skin from the tragal cartilage and soft tissue for better preservation.
- The blind-sac closure is the most vulnerable part of ruptured suture that may lead to open access to the cavity with risk of fat infection. The closure should be performed carefully, always in multiple layers.
- Suturing of the blind-sac closure is done with resorbable surgical threads, because removal of any nonresorbable sutures might open up the wound edges, giving a risk of skin ingrowth or infection of the cavity.
- To reduce risk of fat infection, we harvest abdominal fat shortly before use, and soak it in rifamycin solution (Rifocin 250 mg/3 mL) for 30 minutes.
- Formation of cholesteatoma from residual skin in the cavity is a risk of subtotal petrossectomy. Removal of all skin with the help

of cottonoid and extensive drilling of the bony walls reduce that risk considerably.

- All patients need prolonged postoperative radiologic follow-up using diffusion-weighted MRI.
- Close the eustachian tube tightly to completely separate the cavity from the nasopharynx.
- A retroauricular retraction may develop in a long run due to fat resorption, and it should be informed beforehand. Overfilling of the cavity with abdominal fat will reduce such risk.

Video

See Video 11.1.

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12 Cochlear Implantation in Cholesteatoma Surgery

Patients with profound hearing loss were once considered untreatable. The fitting of a cochlear implant is an innovative technique that totally changed therapeutic strategy of both congenital and acquired sensorineural hearing loss. With this device, as long as the cochlear nerve has kept its integrity, patients with acquired hearing loss have a considerable chance of improving or restoring verbal communication, and infants with congenital hearing loss subsequently may show very good linguistic development. Even though profound bilateral hearing loss is complicated with some pathology, basic requirement for the candidate of cochlear implantation stays the same.

12.1 Indications

General Indications for Cochlear Implantation

Profound (or total) bilateral hearing loss with little or insufficient benefits from conventional hearing aids in the presence of the following:

- Good health condition.
- Motivation to hear (adults).
- Support from the family (children).

In same particular case of cholesteatoma, cochlear implantation is required either in the same stage, or as a second-stage procedure to restore hearing. In contrast to cochlear implantation in normal middle ear in which the electrode array is inserted through posterior tympanotomy, the surgeon should take risk of recurrent disease into consideration. Canal wall down and radical cavities after cholesteatoma surgery force surgeon to place the lead of electrode array close to the surface if the cavity is maintained. Therefore, different strategy to avoid complications needs to be applied.

Indications of Cochlear Implantation with Subtotal Petrossectomy in Cholesteatoma Surgery

Profound (or total) bilateral hearing loss with little or insufficient benefits from conventional hearing aids in the presence of the following:

- Middle ear cholesteatoma.
- Radical or canal wall down cavity with/without inflammation.
- Petrous bone cholesteatoma with preserved cochlea and cochlear nerve.

Recurrence of cholesteatoma in the implanted ear or shallow placement of electrode array in the open cavity gives risks of extrusion of the cochlear implant. If the ear gets infection, the risks of breakdown of the retroauricular skin covering the internal unit and even meningitis arise. Combination of cochlear implantation with subtotal petrossectomy with fat obliteration significantly reduce such danger, since the procedure separates the cavity from external environment and eliminates possibility of recurrent disease. In some cases of petrous bone cholesteatoma, cholesteatoma

is removed with translabyrinthine approach. The labyrinthectomy leads to postoperative ossification and/or fibrosis of the cochlea, making cochlear implantation in future impossible. If the surgeon preserves the cochlea, an electrode array may be inserted in the same stage depending on its necessity.

An electrode is inserted into the scala tympani of the cochlea through either the round window or a cochleostomy created in the promontory. We prefer to use round window approach whenever possible, just because it is more natural anatomically. However, in case of cholesteatoma, the round window is often obliterated with ossification, and need of drilling on the area of the round window is frequently encountered. In addition, the basal turn of the cochlea may be ossified due to inflammatory process, requiring further drilling of the cochlea. To create a cochleostomy in appropriate position in such complicated situations, full anatomical knowledge of the middle ear and inner ear is required.

The surgeon should recognize that insertion of the electrode is just the start of cochlear implantation. Cochlear implantation is a system of therapy that comprises not only surgery but also postoperative fitting and rehabilitation that require a range of other professional skills and teamworking with audiologists, speech therapists, and electrophysiologists. Currently, devices produced by four companies are available in the market. Each device has its own advantages over others, but the indication for any particular patient is not known fully, especially cases with cholesteatoma. Experience with this new device is accumulating, and further studies are required.

12.2 Contraindications

Relative contraindications arise in the presence of active purulent infection with multiresistant microorganisms or tuberculosis. The procedure can be staged when the risk of postoperative infection is considered to be high. In such cases, subtotal petrossectomy with total eradication of the infection under antibiotic coverage is performed in the first stage. After 3 to 6 months when there is no sign of infection, the obliterated cavity is reopened to perform cochlear implantation. The same strategy is applied to cholesteatoma when the surgeon is suspicious of complete removal.

The required surgical steps are shown in cases described below. In contrast to other middle ear procedures, the surgery requires hair shaving and usually facial nerve monitoring.

Case 12.1 (Right Ear): Cochlear Implantation in Acquired Cholesteatoma

See ► Fig. 12.1, ► Fig. 12.2, ► Fig. 12.3, ► Fig. 12.4, ► Fig. 12.5, ► Fig. 12.6, ► Fig. 12.7, ► Fig. 12.8, ► Fig. 12.9, ► Fig. 12.10, ► Fig. 12.11, ► Fig. 12.12, ► Fig. 12.13, ► Fig. 12.14, ► Fig. 12.15, ► Fig. 12.16, ► Fig. 12.17, ► Fig. 12.18, ► Fig. 12.19, ► Fig. 12.20, ► Fig. 12.21, ► Fig. 12.22.

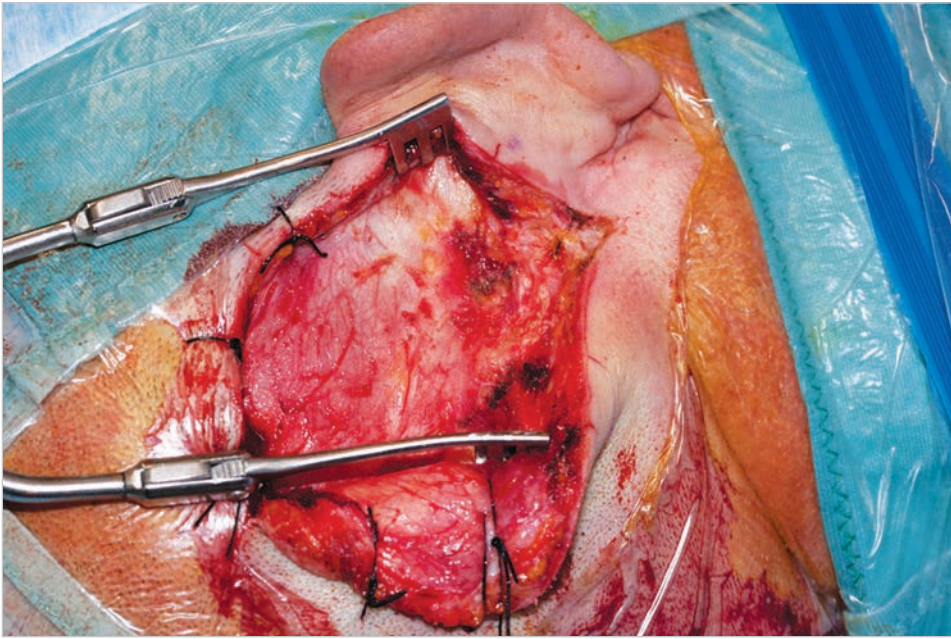


Fig. 12.1 A case of cholesteatoma with profound hearing loss in both ears. An inverted J incision is made in the temporal area to permit wide exposure of the skull for the placement of the internal unit of cochlear implant. The skin and soft tissue are opened in two layers.

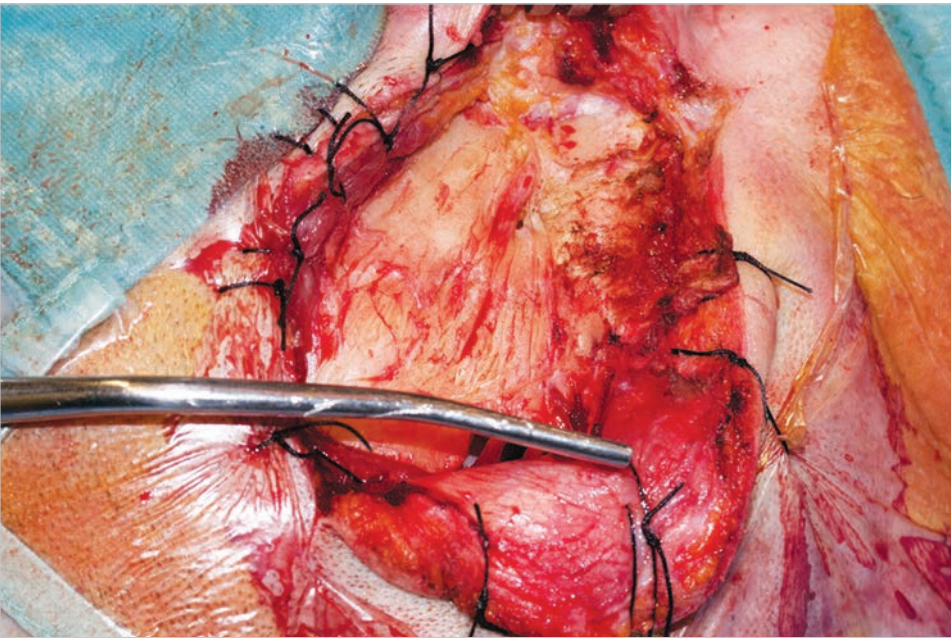


Fig. 12.2 An inverted J incision is made in the temporal area, and the skin and soft tissue are opened in two layers. The opening of the skin is maintained with stitches to maximize its size.

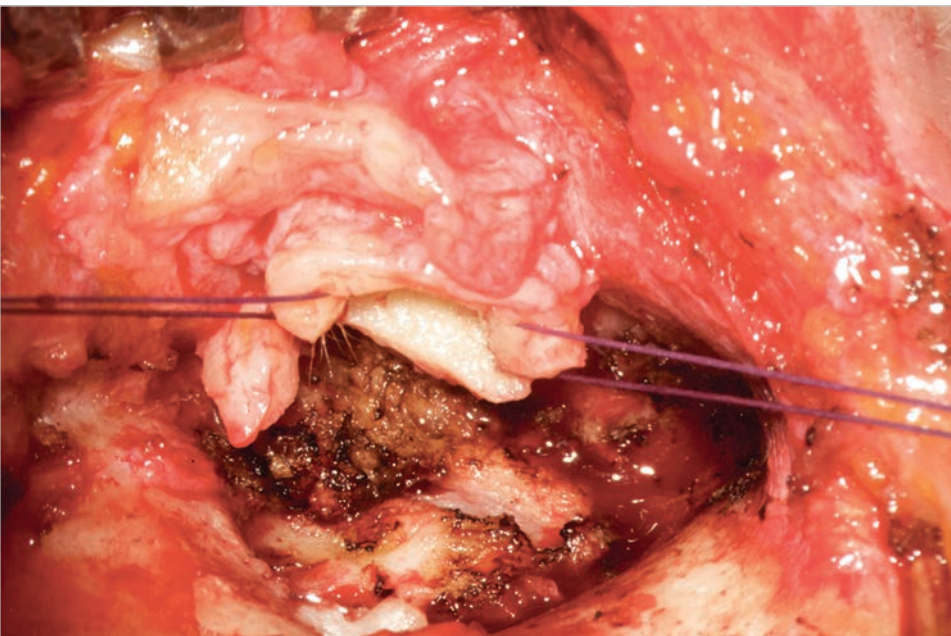


Fig. 12.3 The external auditory canal is closed in two layers. Cartilage of the external auditory canal is removed to mobilize the skin of the cartilaginous portion. Two stitches are placed in the meatal skin to pull it out through the external auditory canal (see Chapter 11).

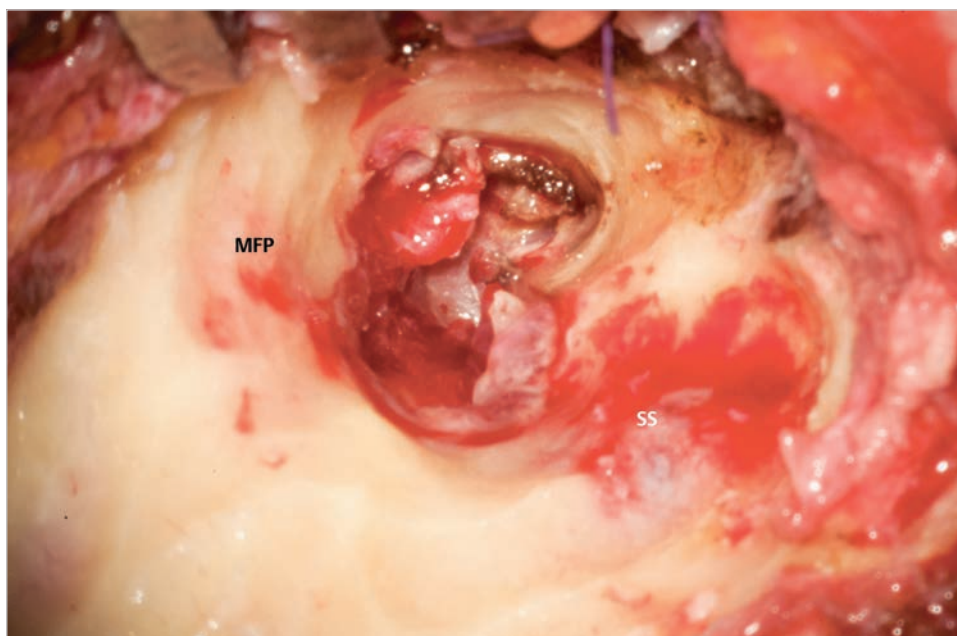


Fig. 12.4 Mastoidectomy is carried out to expose the inflamed canal wall down cavity. The bone near the sinodural angle should not be removed extensively to leave place for the internal unit of implantation. The sigmoid sinus is identified posteriorly, and the middle fossa plate (MFP) superiorly.

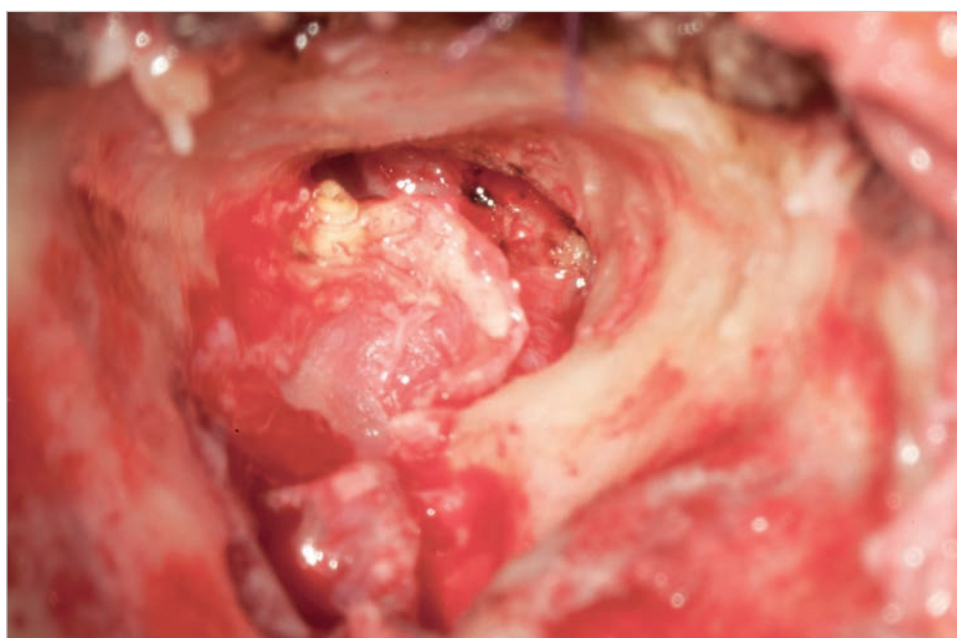


Fig. 12.5 The tympanomeatal flap is detached from the bony annulus to remove it completely.

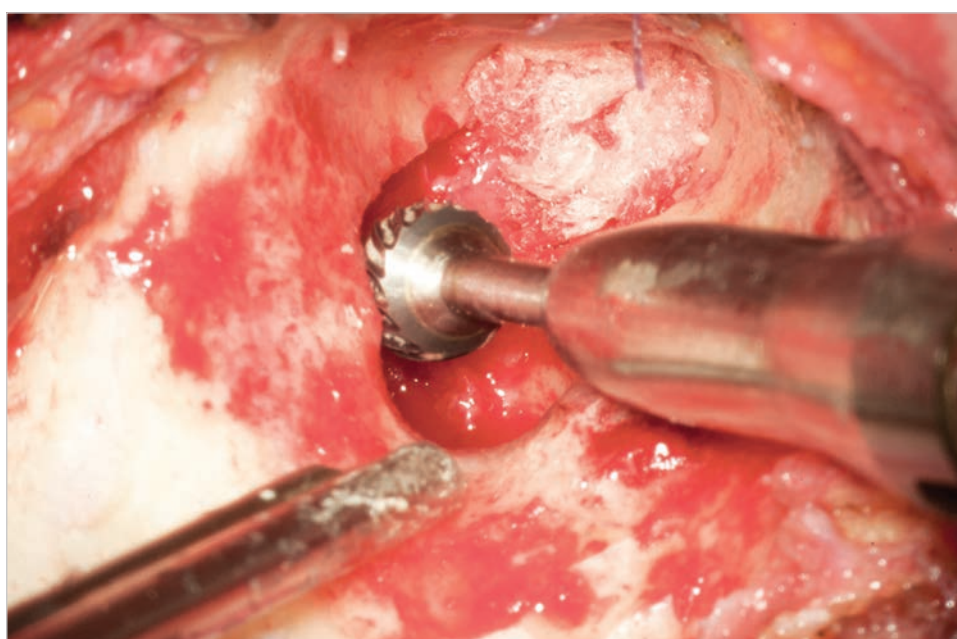


Fig. 12.6 Bony edges in the cavity should be rounded to visualize the cavity well for cholesteatoma removal.

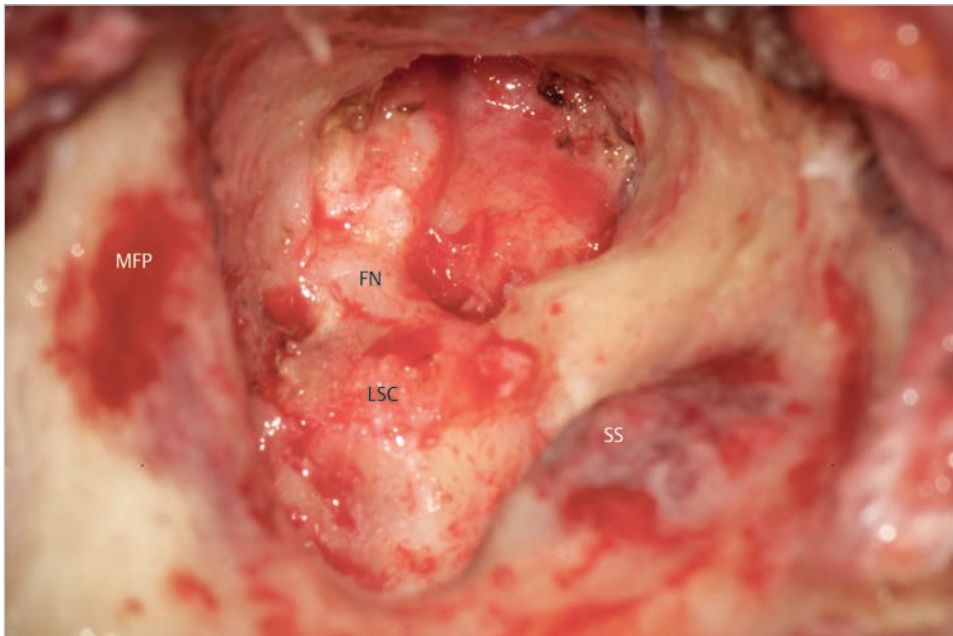


Fig. 12.7 Most part of the skin including cholesteatoma is removed from the middle ear after finishing the bone work. Note the well-rounded cavity. FN, facial nerve; LSC, lateral semicircular canal; MFP, middle fossa plate; SS, sigmoid sinus.

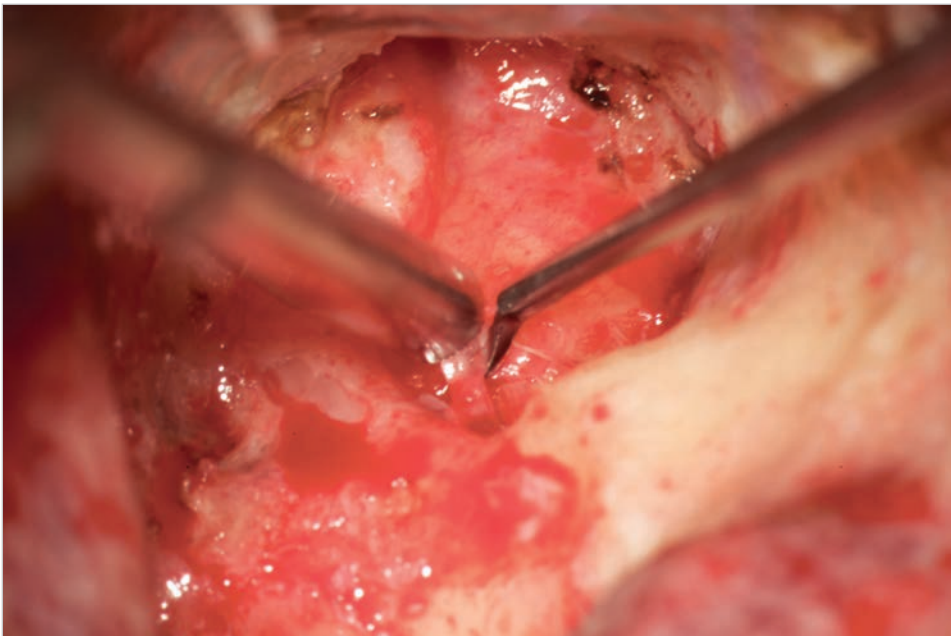


Fig. 12.8 The final piece of cholesteatoma covering the footplate is removed.

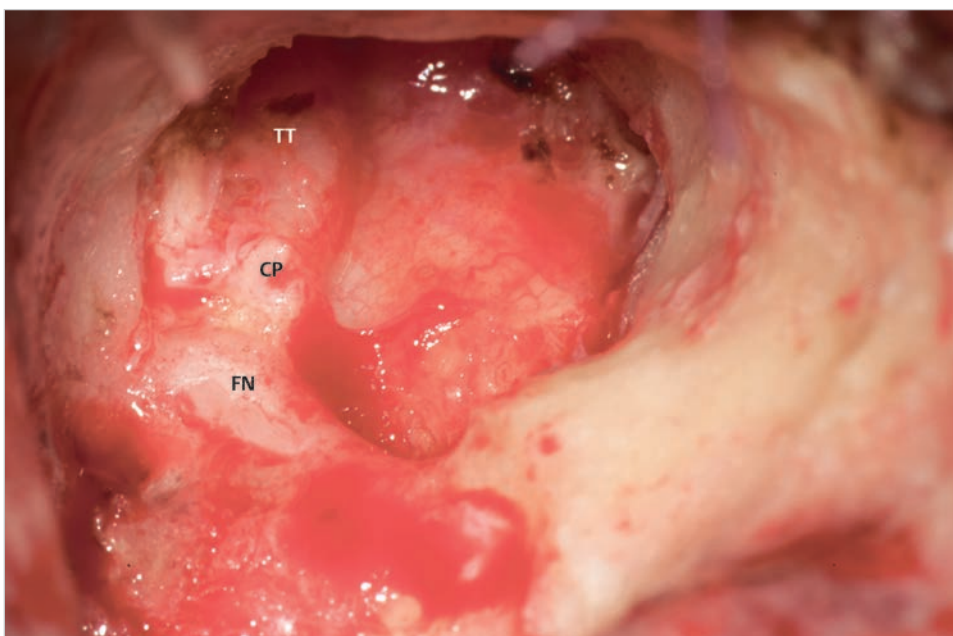


Fig. 12.9 The medial wall of the tympanic cavity is shown. The facial nerve running just superomedially to the cochleariform process is exposed posteriorly to the process. The medial wall of the tympanic cavity is covered with scar tissue. CP, cochleariform process; FN, facial nerve; TT, tensor tympani.



Fig. 12.10 The scar tissue is removed from the area of the footplate (*arrow*). The dissection is advanced inferiorly to expose the promontory and the round window niche. FN, facial nerve; P, promontory.

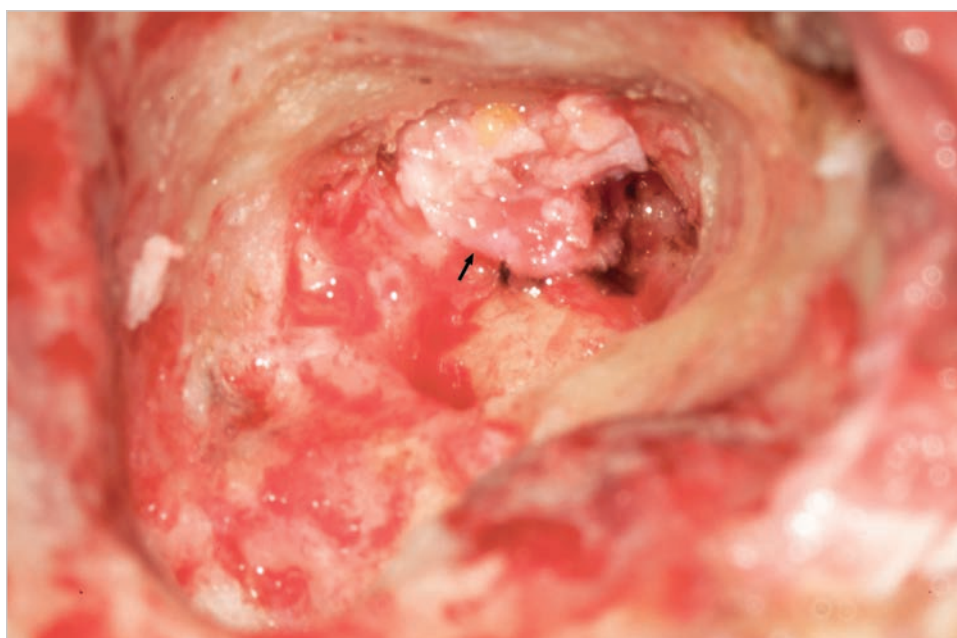


Fig. 12.11 The eustachian tube should be obliterated with periosteum before making a cochleostomy.



Fig. 12.12 Cleaning of the medial wall is completed. The footplate of the stapes and the round window niche are visualized clearly. CP, cochleariform process; FN, facial nerve; FP, footplate; JB, jugular bulb; RWN, round window niche.



Fig. 12.13 Scar tissue in the round window niche is removed. The round window membrane forming the anterosuperior wall of the niche seems to be ossified. FN, facial nerve; FP, footplate; RWN, round window niche.

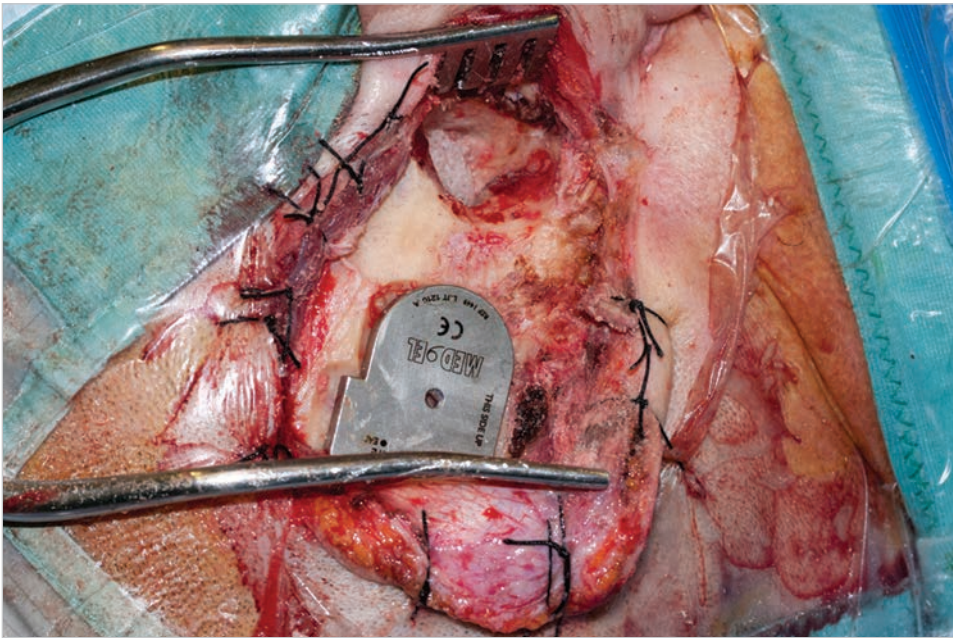


Fig. 12.14 Preparation of the cochlear implantation should be completed just before opening the cochlea. A dummy of the internal unit is used to create a bed to accommodate it properly.

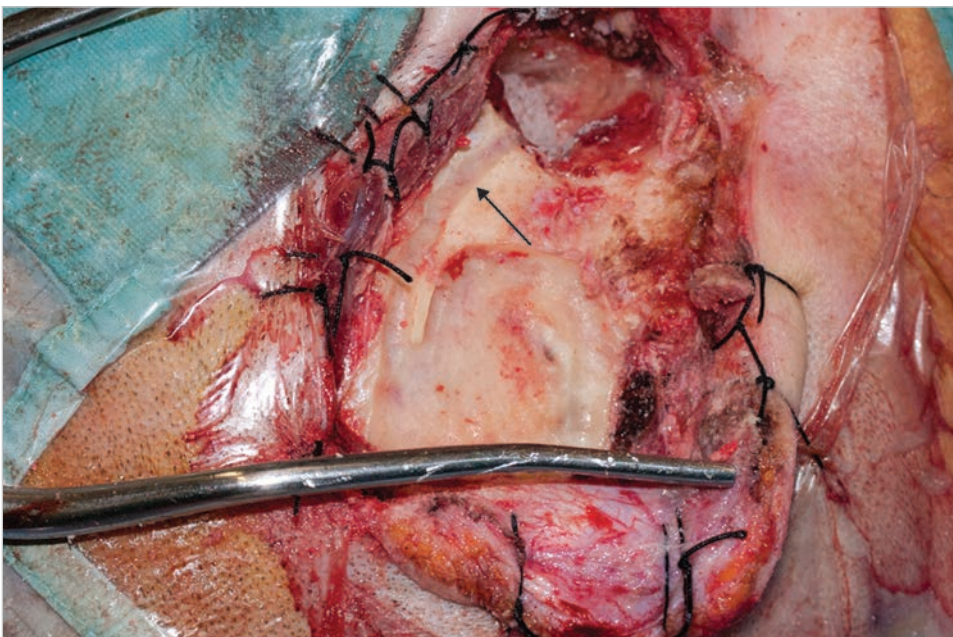


Fig. 12.15 A bed for the internal unit is created behind the inflamed cavity. A groove for the electrode connecting the bed and the cavity is seen (arrow).

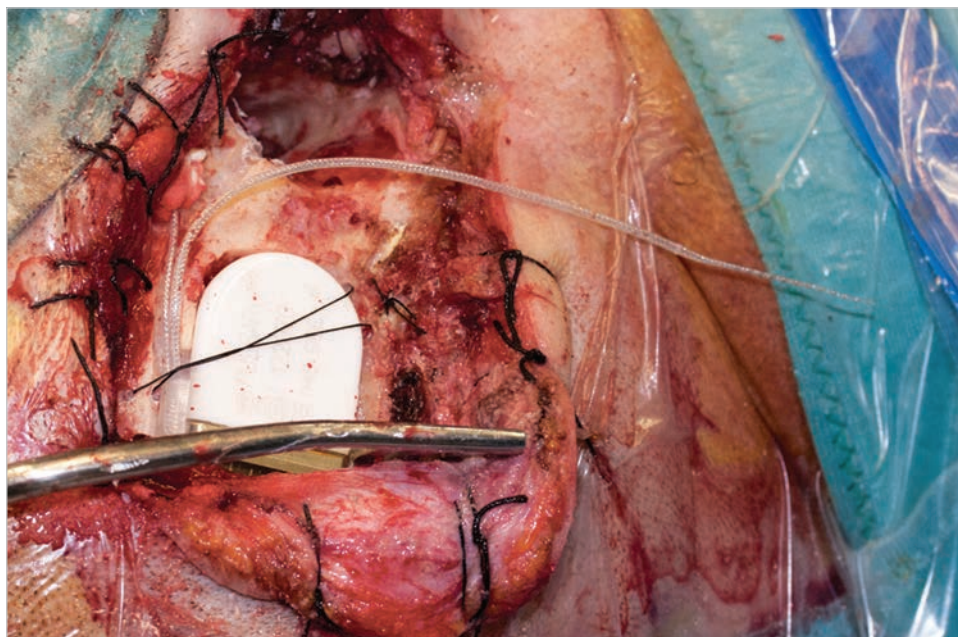


Fig. 12.16 Holes for stay sutures have been created around the bed using small burrs. After placing the internal unit in appropriate position, a nonabsorbable surgical thread is used to fix it. An inflamed cavity is seen anteriorly to the internal unit.



Fig. 12.17 The roof of the round window niche is drilled to see clearly the round window membrane.



Fig. 12.18 The ossified round window niche is shown.

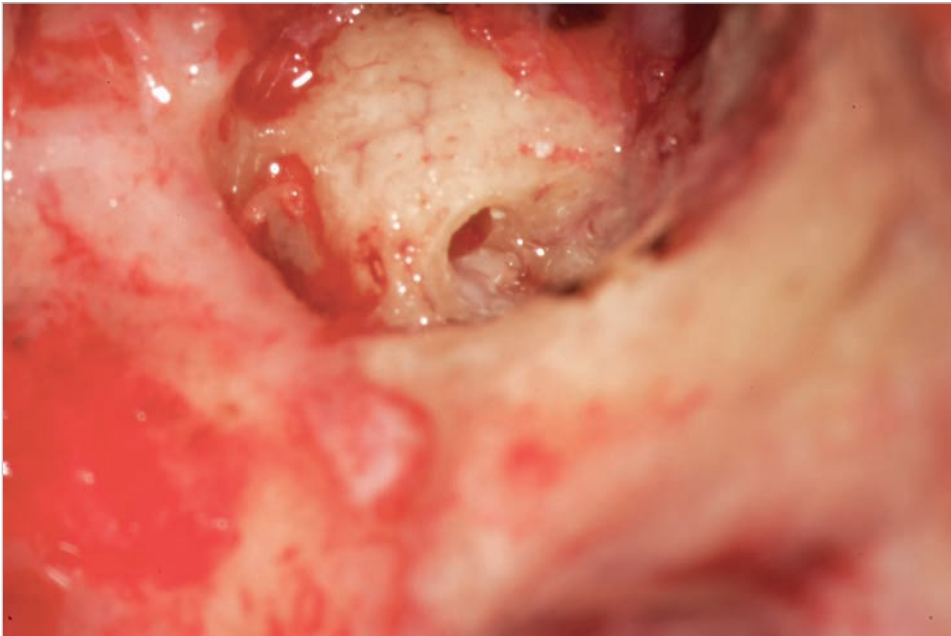


Fig. 12.19 Further drilling over the area of the round window opens the scala tympani of the basal turn.

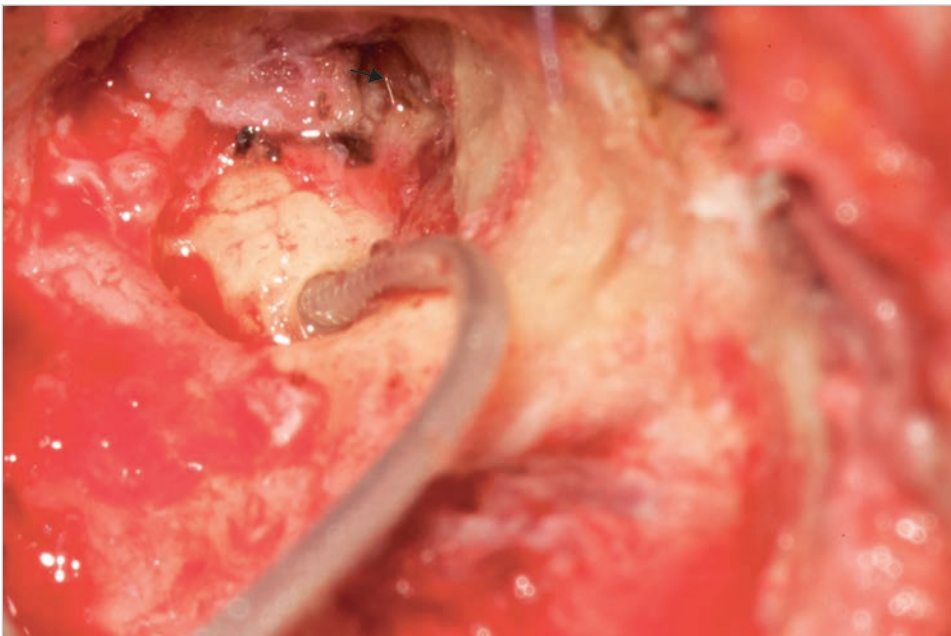


Fig. 12.20 An electrode array is introduced into the cochlea. The eustachian tube should be closed (*arrow*) with periosteum before making cochleostomy.

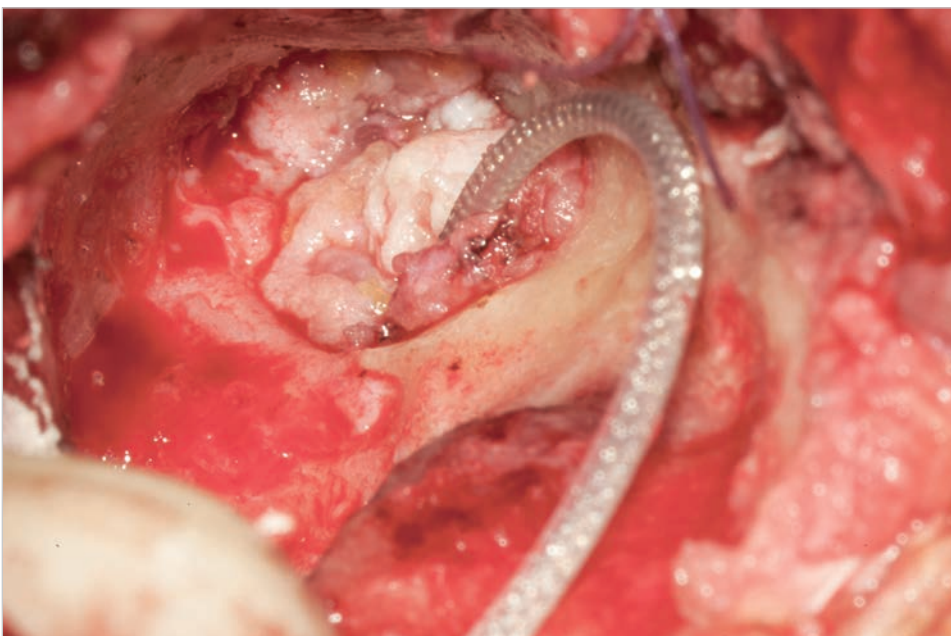


Fig. 12.21 The cochleostomy is closed, and the electrode array is stabilized with pieces of periosteum. The cavity is packed with abdominal fat.

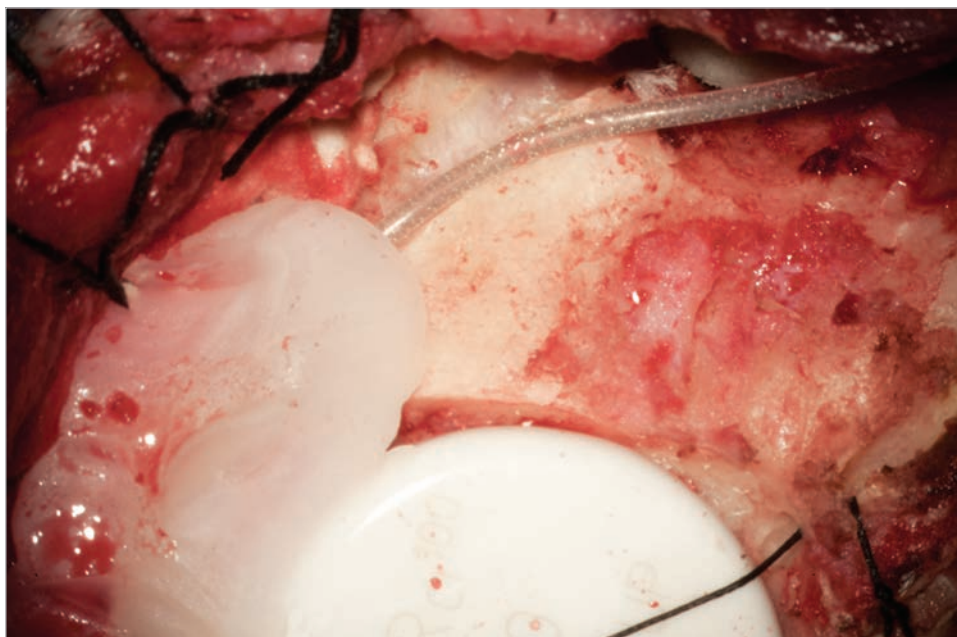


Fig. 12.22 The electrode is fixed to the cortical bone with bone wax.

Case 12.2 (Right Ear): Cochlear Implantation in Recurrent Cholesteatoma in a Canal Wall Down Cavity

See ► Fig. 12.23, ► Fig. 12.24, ► Fig. 12.25, ► Fig. 12.26, ► Fig. 12.27, ► Fig. 12.28, ► Fig. 12.29, ► Fig. 12.30, ► Fig. 12.31, ► Fig. 12.32, ► Fig. 12.33, ► Fig. 12.34, ► Fig. 12.35, ► Fig. 12.36.

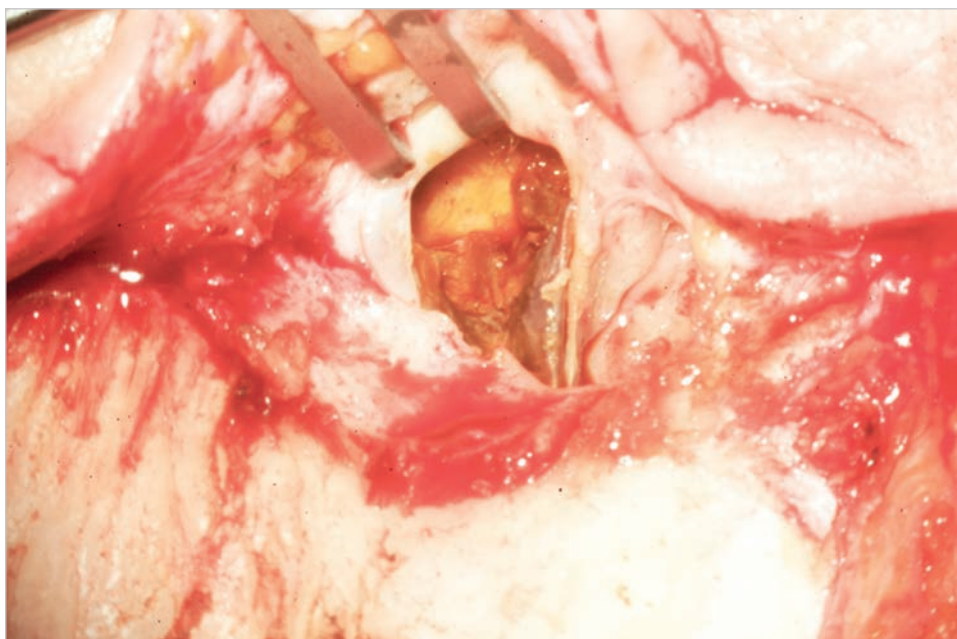


Fig. 12.23 A case of recurrent cholesteatoma after canal wall down technique is performed elsewhere. Cochlear implantation is indicated based on preoperative hearing examination showing profound hearing loss in both ears.

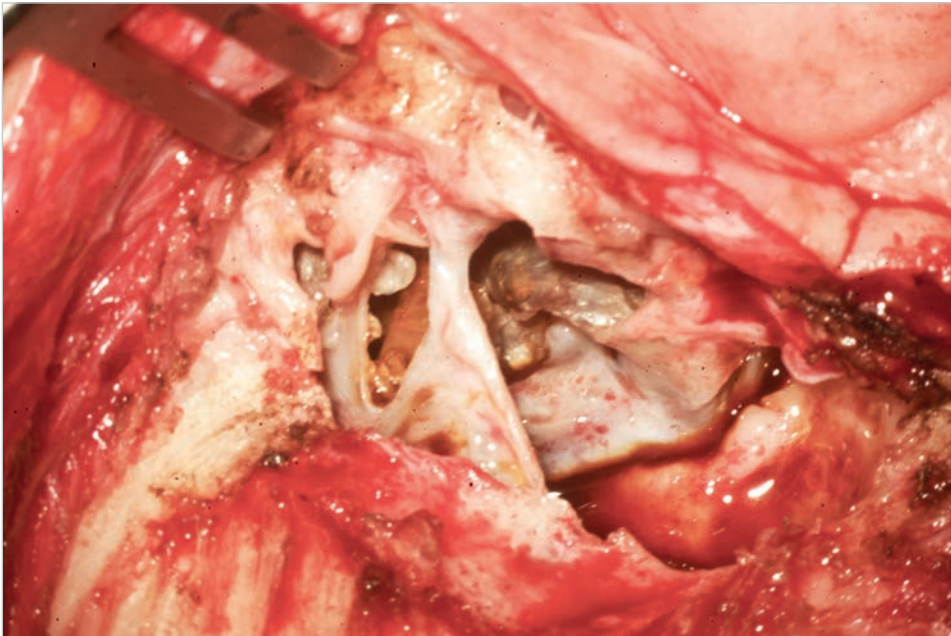


Fig. 12.24 Cholesteatoma has recurred in a badly performed cavity. Accumulation of debris in the mastoid cavity is seen.

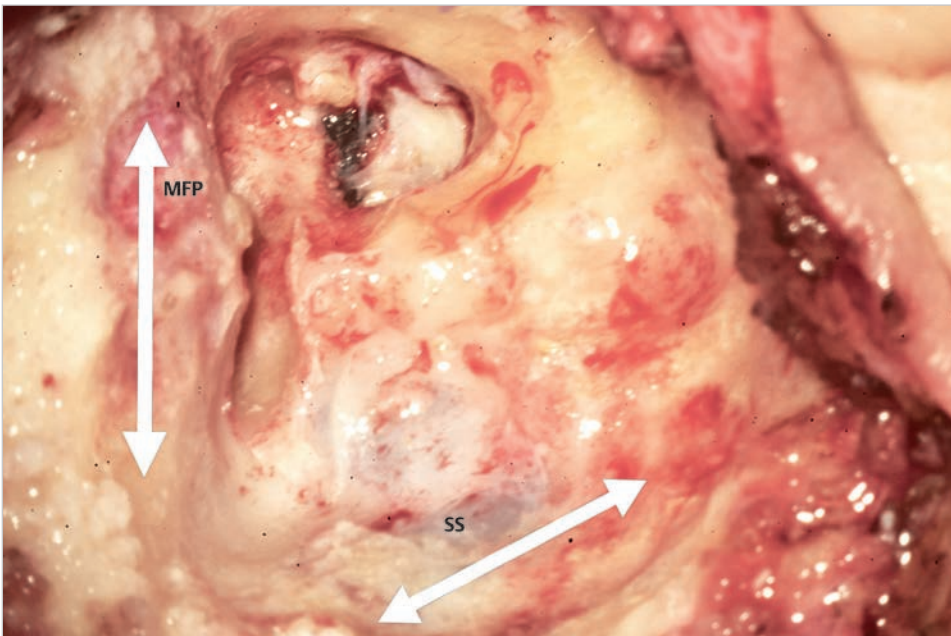


Fig. 12.25 Mastoidectomy is started in wide area to identify the middle fossa plate and the sigmoid sinus superiorly and inferiorly, respectively. To identify these structures safely, drill should be moved parallel to structures as indicated by arrows. MFP, middle fossa plate; SS, sigmoid sinus.

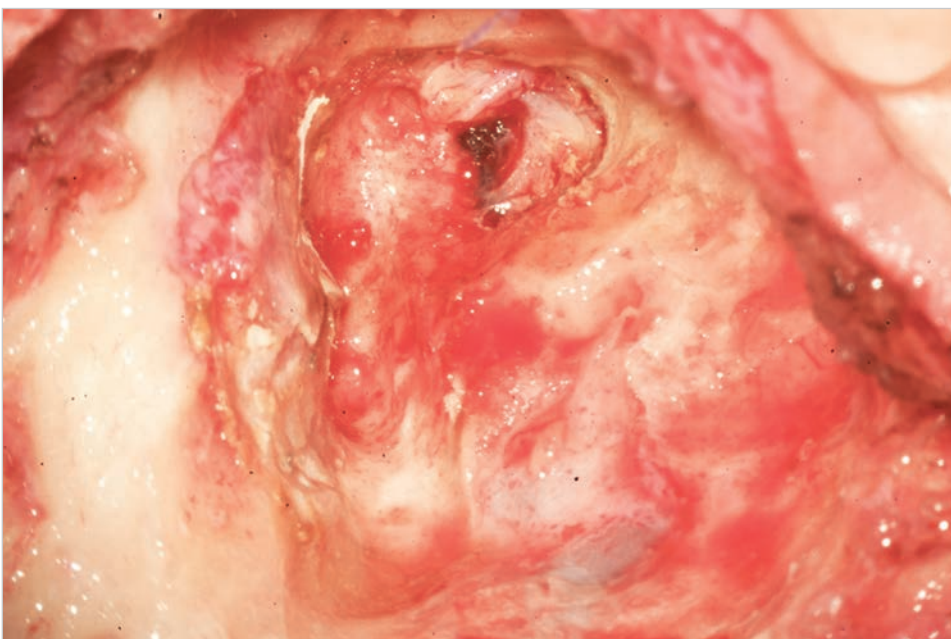


Fig. 12.26 Most part of the cholesteatoma is removed from the middle ear except the tympanic cavity. Lowering of the facial nerve facilitates removal of pathologic tissue from the area near the posterior wall of the tympanic cavity.



Fig. 12.27 The tympanic cavity filled with scar tissue is shown. The posterior half of the tympanic membrane.

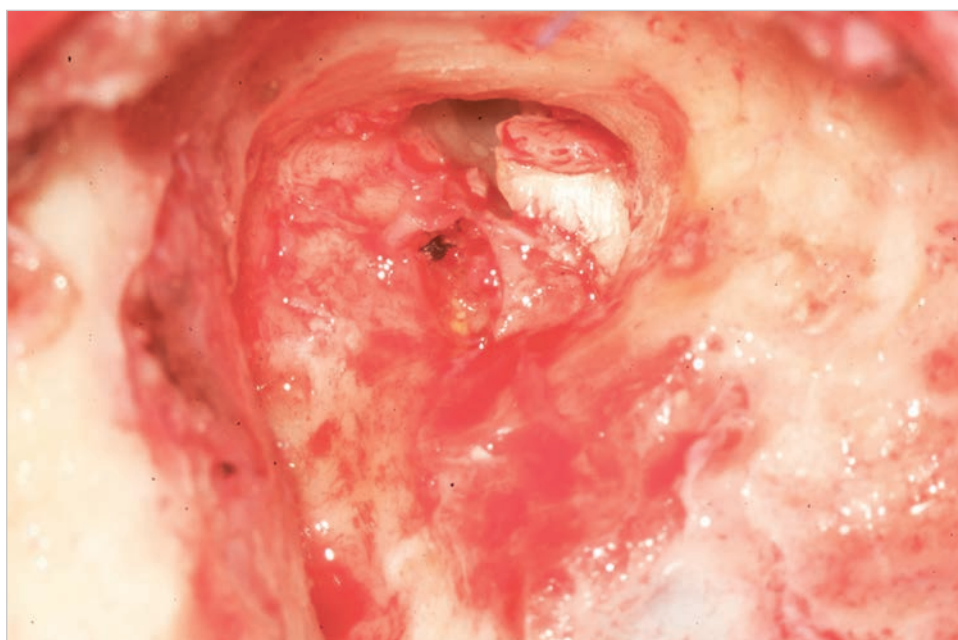


Fig. 12.28 Residual cholesteatoma infiltrating hypotympanic cells is identified under the scar tissue.

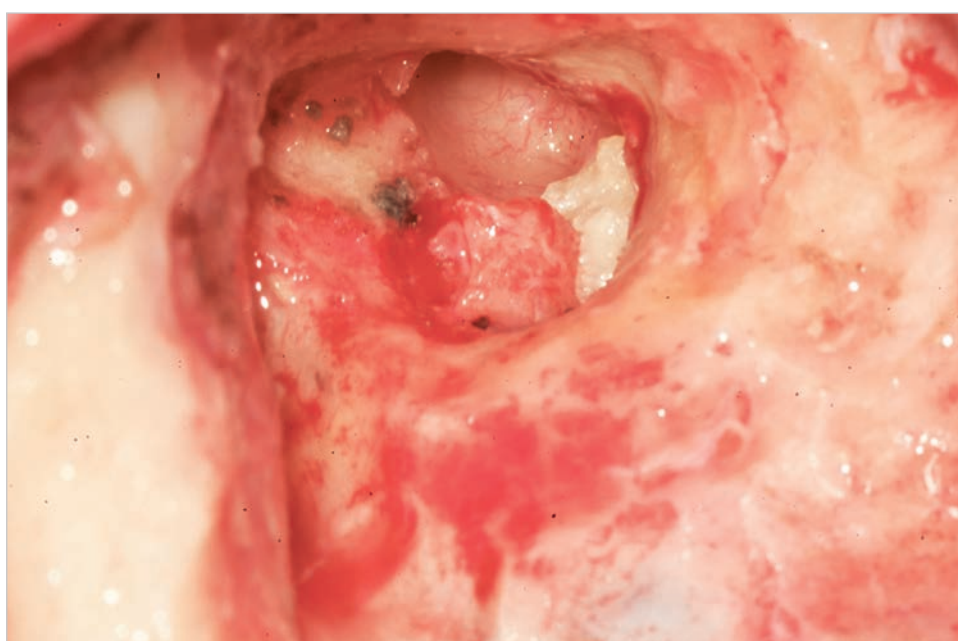


Fig. 12.29 The debris is reduced to expose the promontory. Note a large tympanosclerotic covering the promontory to reach both the round window niche and the stapes.



Fig. 12.30 Hypotympanic cells infiltrated by cholesteatoma are opened.

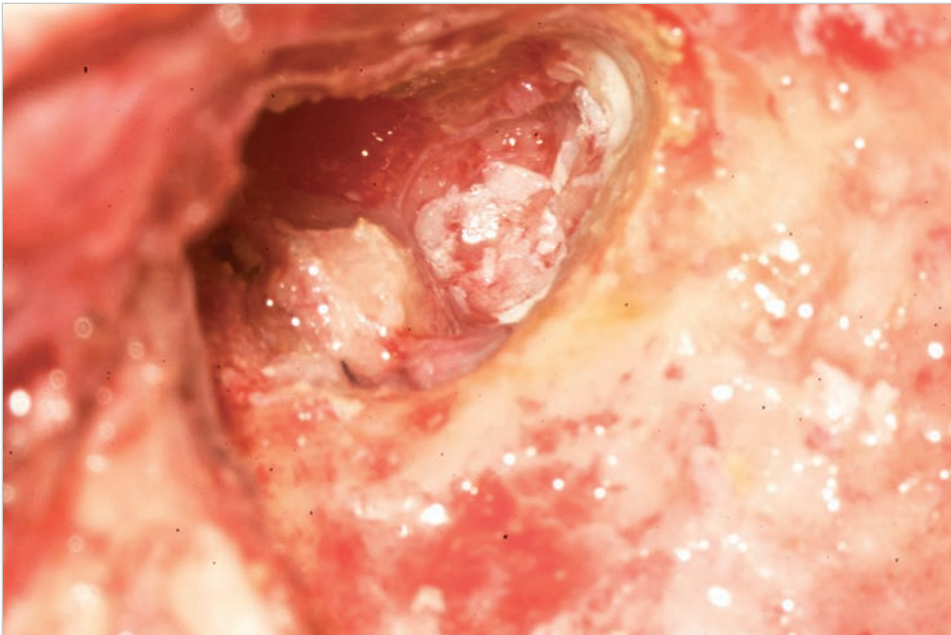


Fig. 12.31 The tympanic bone covering the cholesteatoma is drilled out to expose the pathology fully, and the tympanosclerotic plaque covering the promontory is reduced. Ch, cholesteatoma; P, promontory.

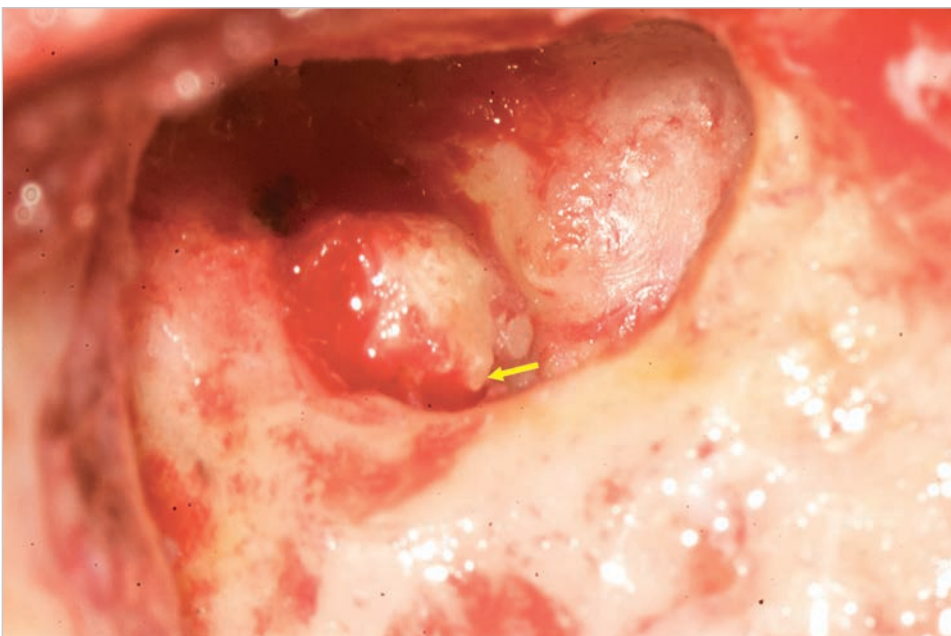


Fig. 12.32 Cholesteatoma is eradicated from the middle ear. Note the large tympanosclerotic plaque covering the promontory. The plaque filling the round niche (arrow) is reduced gradually to reach the area of the round window membrane.

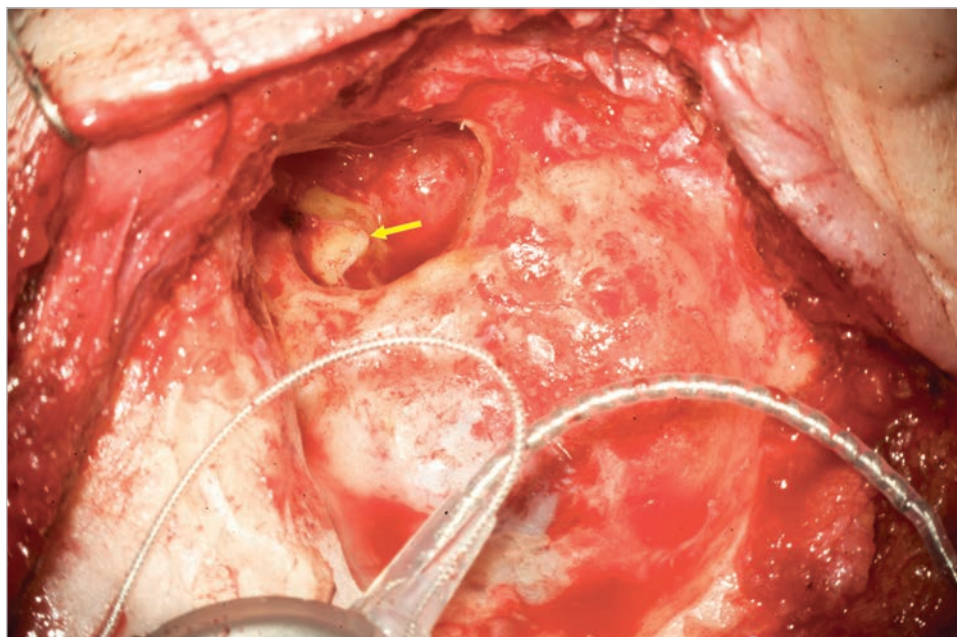


Fig. 12.33 After finishing preparation of the bed for the internal unit, the tympanosclerotic plaque covering the round window will be started to be reduced (*arrow*). During the procedure, the internal unit should be kept aside.



Fig. 12.34 Further drilling over the area of the round window opens the basal turn of the cochlea. The opening has been enlarged with a gentle drilling to allow insertion of the electrode. The internal unit is fixed to the bed, and the electrode array is ready to be inserted.

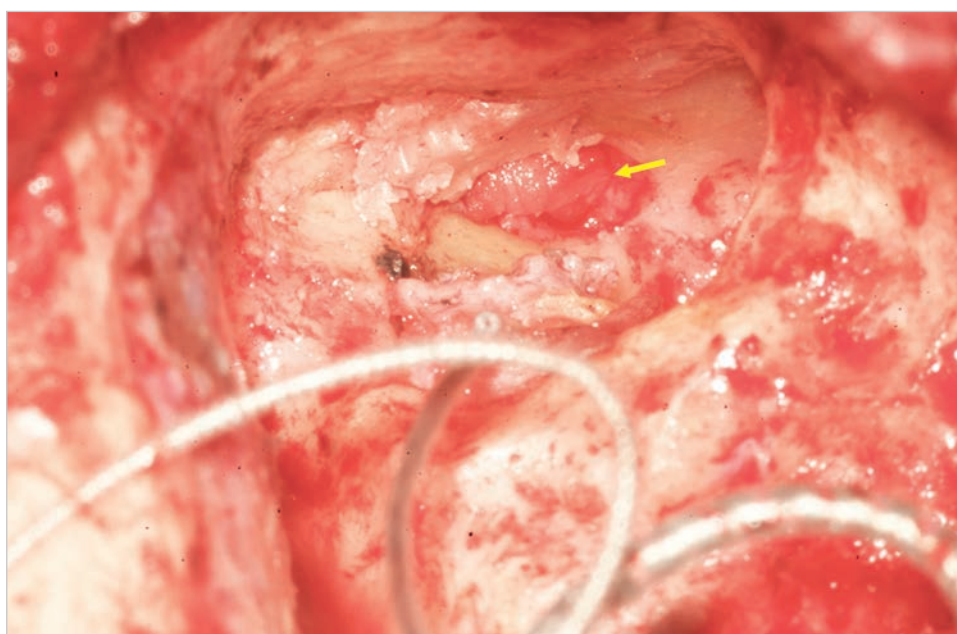


Fig. 12.35 The eustachian tube is closed with pieces of periosteum (*arrow*). The electrode array is introduced into the cochlea, and the opening is closed with pieces of connective tissue.

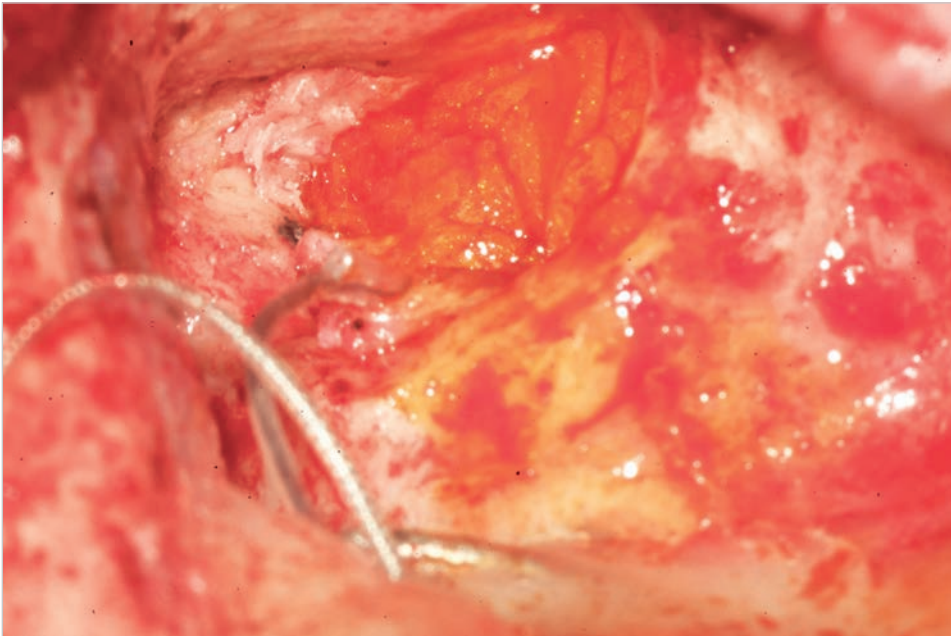


Fig. 12.36 The cavity is packed with abdominal fat.

Case 12.3 (Left Ear): Cochlear Implantation with the Obliterated Round Window Niche in a Canal Wall Down Cavity

See ► Fig. 12.37, ► Fig. 12.38, ► Fig. 12.39, ► Fig. 12.40, ► Fig. 12.41, ► Fig. 12.42, ► Fig. 12.43, ► Fig. 12.44, ► Fig. 12.45.



Fig. 12.37 The patient had undergone left middle ear surgery with canal wall down technique. The skin covering the cavity and the tympanic membrane are completely removed, and the cavity was rounded. The round window niche and the oval window are completely obliterated with tympanosclerosis.



Fig. 12.38 The area of the round window is drilled gradually by using the facial nerve and the cochleariform process as landmarks. In many cases after drilling, color of ossified plaque is different from that of bony capsule of the inner ear, and this may help to locate the round window. To avoid opening the vestibule, the drilling is started from inferior, where the scala tympani in the basal turn exists.



Fig. 12.39 The round window is about to be exposed. Note that the color of the original otic capsule is slightly different from pathologic ossification in this case.

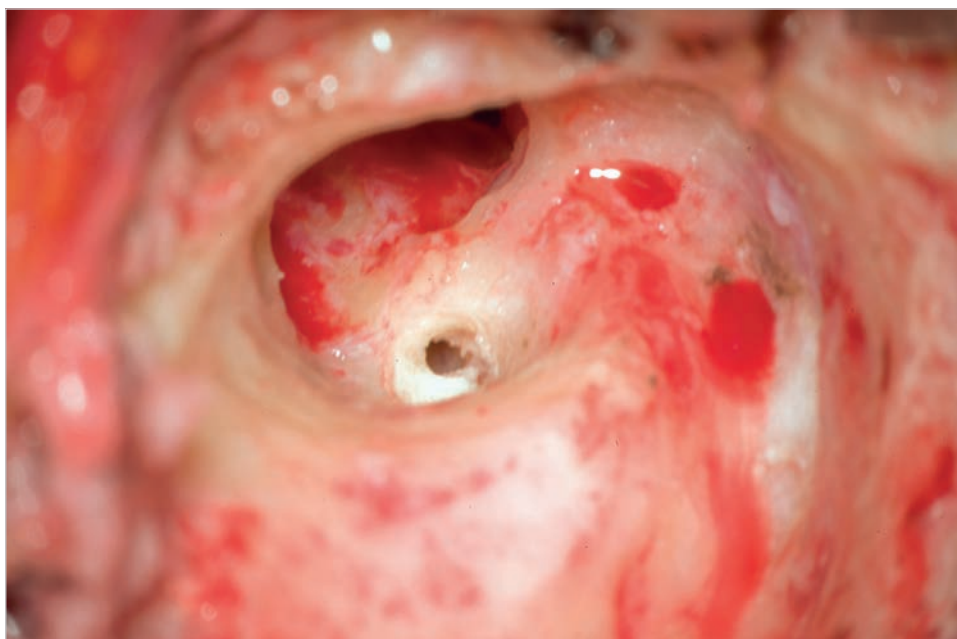


Fig. 12.40 The round window is opened.



Fig. 12.41 To prepare for the internal unit, the opening of the cochlea is covered with Spongel soaked in saline solution.

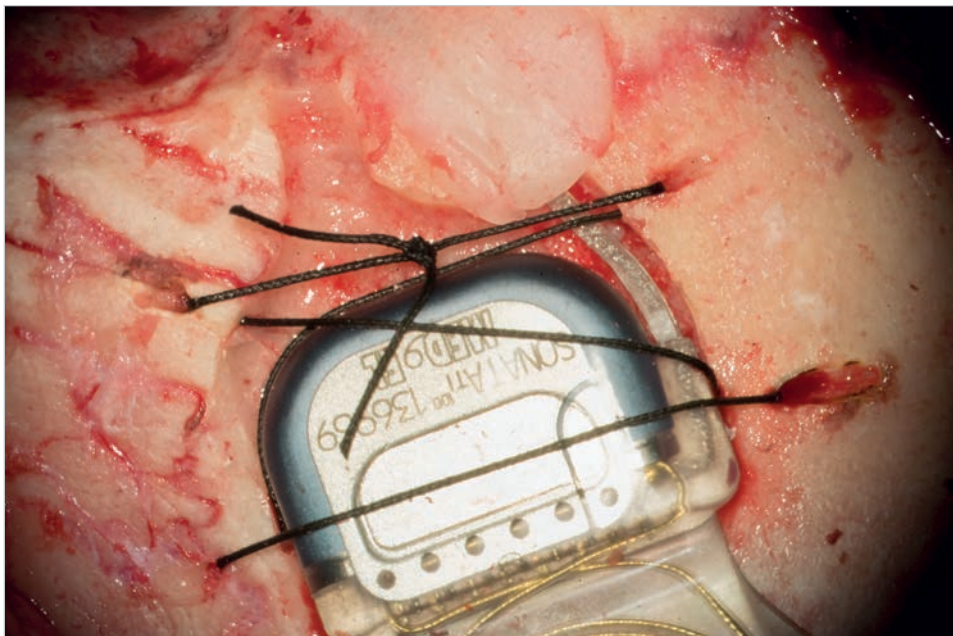


Fig. 12.42 The device requires creation of a bed on the surface of the skull and need to be fixed with nonabsorbable thread.

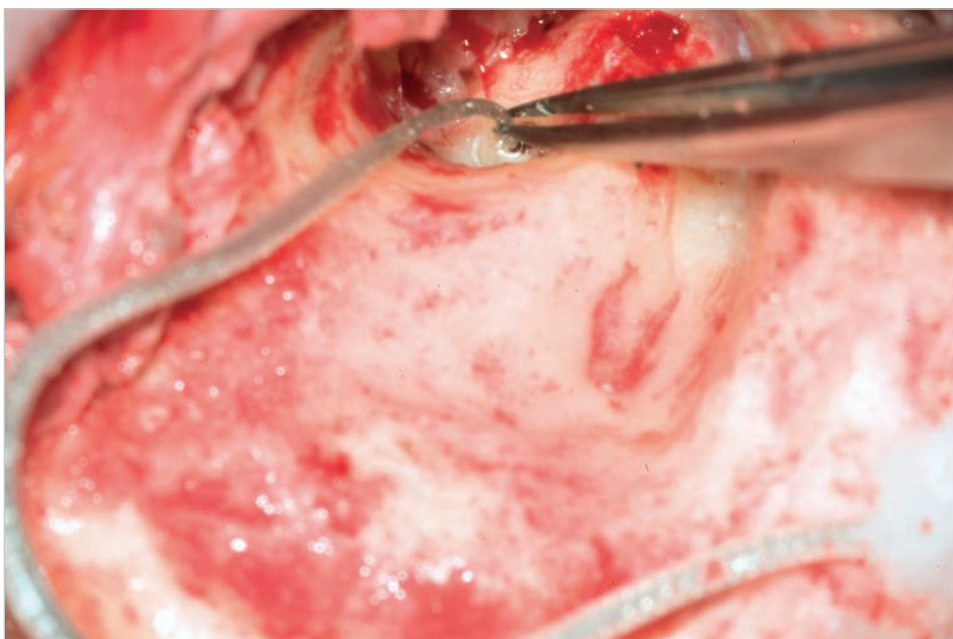


Fig. 12.43 The electrode array is inserted into the cochlea.

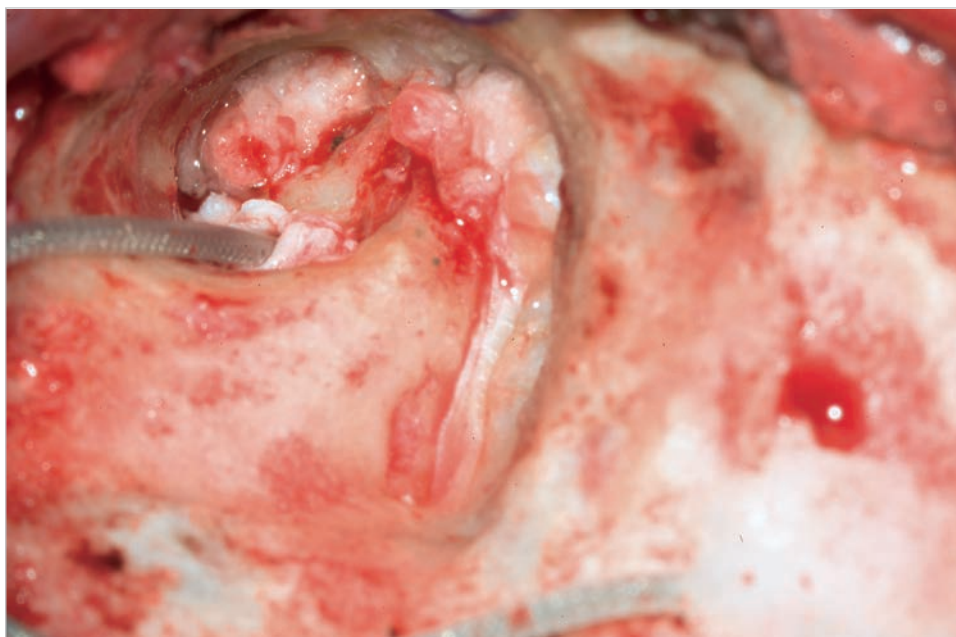


Fig. 12.44 The round window is sealed with pieces of connective tissue. Opening of perilymphatic cells are closed with some connective tissue.

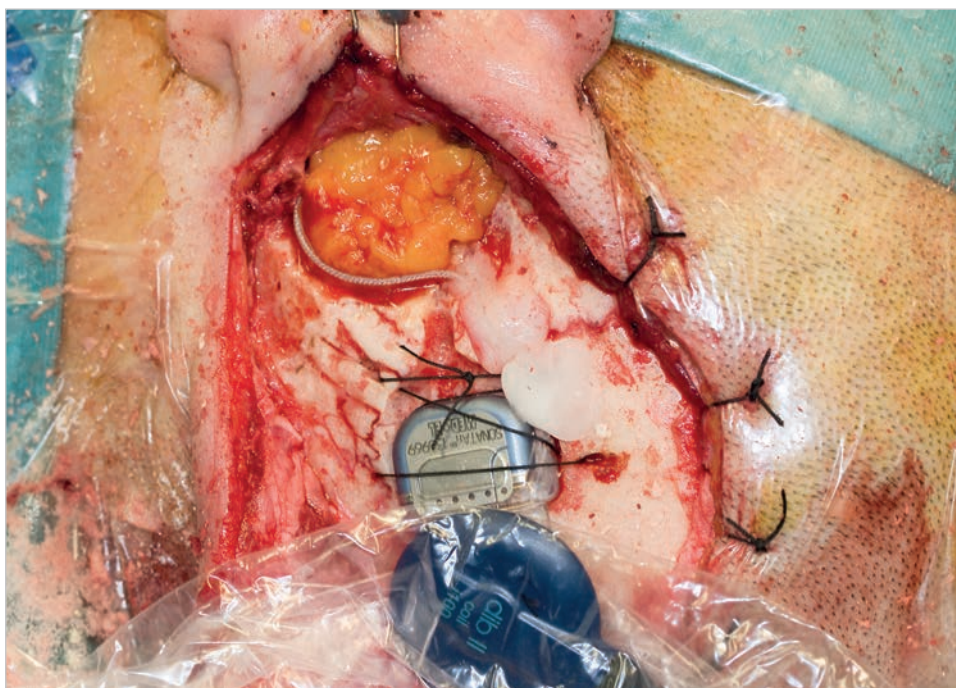


Fig. 12.45 The electrode array is checked for resistance of each electrode, and for inadvertent facial nerve stimulation by using the facial nerve monitoring and by observing movement of stapedial muscle. Bone wax is applied to fix the electrode. The stimulator should be covered to keep sterilized condition. The cavity is obliterated with abdominal fat, and the wound is closed in three layers.

12.3 Hints and Pitfalls

- Subtotal petrosectomy in one stage is indicated in cases with previous middle ear surgery.
- The round window is the natural way for electrode array insertion.
- We *do not* recommend cochleostomy whenever it is possible. This technique is much more difficult, and more dangerous than the round window route.
- Do not search the round window niche directly when it is covered by pathology. Exposure of the medial wall should be started from inferior forms hypotympanic cells. The promontory is identified next, and the round window niche is located just posterior to it. This avoid damaging the facial nerve that may be exposed under the pathologic tissue.
- The round window is often covered by a bony ridge, and not directly visible. The bone covering the round window should be drilled out. Whole membrane of the round window should be visualized.
- Before opening the round window membrane, the implant must be secured on the skull, and ready to be inserted.
- The window should be opened with great care. Never use the suction over the opened window to avoid damaging intracochlear structures.
- Do not put excessive force during insertion of the array. If there is any friction, stop insertion, and pull back the array slightly. Some rotatory movement may help.
- The cochlea must be opened at the end of all bone work. Care must be taken not to allow for blood and bone dust entering the cochlea.
- In case of drill out procedures in which the basal turn or middle turn of the cochlea is opened, larger access to the cochlea increases risk of meningitis, and also of extrusion of the array. The array should be carefully fixed with fascia, muscle, and fibrin glue preferably in several layers. An extra tight filling with fat over the cochlea is advisable.
- A wider skin incision, more drilling and a fat-filled cavity sometimes results in a lower position of the auricle (0.5–1 cm).

This can be of aesthetic value to the patient and needs to be informed preoperatively.

- In subtotal petrosectomy, it is advisable to fixate the receiver–stimulator because of the wider incision.
- After subtotal petrosectomy with cochlear implantation, extra care for hemostasis should be taken. A tight head bandage is kept in place for at least 48 hours.
- Follow-up with imaging is required after subtotal petrosectomy with cochlear implant because of the risk of entrapped cholesteatoma. Even though magnetic resonance imaging (MRI) up to 1.5 Tesla can be used safely after application of a head bandage to fixate the implant (Wackym 2004, Crane 2010), visibility of a possible cholesteatoma on MRI will be impeded due to the presence of heavy artifacts. Removal of the magnet is not recommended, since it hardly improves visibility and may lead to infection of the surgical site and weakening of the pocket carrying the magnet.
- Instead of MRI, computed tomography (CT) at 1, 3, 5, and 10 years postoperatively is a good option for follow-up. The

power of the CT in this particular situation is enhanced by the presence of the abdominal fat that creates an ideal interface against cholesteatoma. Repeated CT may proof growth, and thus give more support for presence of cholesteatoma.

Video

See Video 12.1.

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13 Management of Iatrogenic Injuries in Middle Ear Cholesteatoma Surgery

Surgeons have to deal with various pathologies such as granulation tissue, scar, and cholesteatoma located near very fine, fragile structures that are obscured by bony structures. Three-dimensional anatomy of these fine structures in the temporal bone is complicated. Surgeons need to find and utilize consistent landmarks during surgery. However, the anatomy may be distorted by the pathology, former surgery, and anomalies of the middle ear. Trial to remove either pathologic tissue or obstructing bone may eventually cause undesired surgical complications even in most experienced hands. At any rate, patients should be preoperatively informed of various risks, and surgeons should be well prepared for these situations.

The best way to minimize the risk is to refine knowledge of temporal bone anatomy with continuous efforts in temporal bone dissection laboratory, and to keep fellowship with tertiary referral centers where frequent visits for observing surgery is permitted. If the surgeon faces iatrogenic injuries that seem to be difficult to solve by himself or herself, do not waste precious time just to watch the clinical course. Send the patient to the referral center.

13.1 Bleeding from the Dura

Bleeding from the dura is managed by bipolar coagulation with minimal power. *Monopolar coagulation is prohibited* since it may create a hole on the dura. If troublesome bleeding occurred between the bony shell and the dura, Surgicel is inserted under the bone. The Surgicel may be left in place at the end of the surgery. The exposed dura may be covered with the temporalis fascia.

13.2 Bleeding from the Sigmoid and Other Sinuses

If the sinus is covered with bone, drilling with a large diamond burr is tried. If the bleeding does not stop, bipolar coagulation may be applied. Again, do not use monopolar coagulator to avoid further damaging the sinus. If bleeding sustains, Surgicel is placed on the tear and pressure is applied over it by placing cottonoids. Leaving this material in place eventually stops bleeding. After removing the Surgicel, bipolar coagulation is applied to ensure closure of the tear, or the Surgicel may be left in place. The sigmoid sinus exposed in the open cavity is covered with bone paté and fibrin glue, and the temporalis fascia is placed. Bleeding from the superior and the inferior petrosal sinuses may be managed by packing the sinus with Surgicel.

13.3 Bleeding from the Jugular Bulb

If the high jugular bulb is exposed in the hypotympanum without bony coverage and the situation is not recognized, the surgeon may tear its wall during some maneuvers such as elevation of the fibrous annulus.

In transcanal approaches, the tympanic cavity is tightly packed with sufficiently large Surgicel to avoid pulmonary embolization. Massive bleeding from the tympanic cavity usually forces surgeon to give up any further manipulation to the middle ear. The tympanomeatal flap is replaced, and the external auditory canal is tightly packed with Gelfoam in such cases.

In retroauricular transmastoid approaches, the area of bleeding is first packed with large pieces of surgical. After placing pieces of cottonoid over that area to ensure tight packing, operation can be continued in other areas. Leaving these materials usually stops bleeding. After achieving complete hemostasis, the cottonoids are gently removed to complete the surgery. The Surgicel is left in place and the skin is closed.

13.4 CSF Leak

Cerebrospinal fluid (CSF) leak into the middle ear may occur when the dura is insulted during removal of middle ear pathology and drilling the bone, usually with cutting burrs. In cases with bony defect such as large cholesteatoma and revision surgery, the dura may protrude into the middle ear, and may be easy to damage if care is not taken. The dura becomes thin and fragile, especially in the area of the middle fossa of elderly patients.

The CSF leak may be classified into two situations. (1) If the arachnoid membrane is not insulted, the leak may be small and easily stopped. A small dural opening can be repaired by a small piece of either periosteum or muscle inserted into the tear. The piece is fixed with fibrin glue. Larger openings are closed by a piece of muscle or periosteum and sutured to the dura. Bony defects are repaired by inserting a sufficiently large piece of cartilage (either autologous or homologous) beneath the bone. The defect is further covered with a sufficiently wide fascia fixed with fibrin glue. (2) If the arachnoid membrane is insulted, more CSF flows out from the subarachnoid space, and risk of postoperative CSF leak followed by meningitis may be higher with usual treatment. In such cases, radical mastoidectomy, closure of the eustachian tube, obliteration of the cavity with abdominal fat, and blind-sac closure of the external auditory canal are employed (see Chapter 11).

Postoperatively, absence of sustained leakage should be checked by asking the patients whether there is any rhinorrhea or postnasal drip especially in recumbent position. Tilting the head forward in sitting position may reveal some serous fluid coming out from the eustachian tube. If CSF leak sustains postoperatively, spinal drainage is introduced and the patient is carefully observed for a few days. If the leak lasts more, revision surgery is indicated.

13.5 Labyrinthine Fistula

Opening of the labyrinth may occur during drilling or dissection of pathologic tissue from bony structures in the area of the labyrinth (see Chapter 10). If the fenestration of the labyrinth

is recognized immediately after it happens, bone wax may be applied as soon as possible to obliterate the opening. The other option is to use small piece of fascia to cover it and fibrin glue is applied for fixation. The area is further covered by a large fascia in the end of operation. If labyrinthine fistula is suspected but not sure, useful technique is to push the stapes gently with a small hook. Any movement of that area under microscope indicates presence of a fistula. Fenestration sometimes occurs anteriorly in the lateral semicircular canal, close to the ampulla. In such cases, even after immediate closure, postoperative sensorineural hearing loss may follow.

13.6 Disarticulation of the Incus

Excessive force on the incus during manipulation of pathologies around the ossicular chain or inadvertent drilling near the short process of the incus may cause disarticulation of this ossicle. Unawareness and/or leaving this status may result in postoperative uncoupling of the tympanic membrane and the stapes. The disarticulation easily occurs when the incudomalleal joint is eroded. Removal of the incus after complete disarticulation of the incudostapedial joint is required in such cases. Ossiculoplasty is performed in either the same or the second stage, depending on the status of the pathology.

13.7 Fracture of the Stapes

The stapes is the smallest and the finest bone in the human body. The average height and length of each of the long axis of the footplate are about 3 mm. The structure may easily be insulted with reckless maneuvers, especially when the bone is involved in some pathology. If the superstructure is fractured, it should be removed (using sharp straight malleable scissors) and ossiculoplasty is performed in the same or the second stage. If the footplate is fractured, protection of the inner ear has to be the primary concern. If the superstructure is present, some blood is dropped on the footplate to seal the inner ear. If the superstructure is missing, a small piece of fascia is used to cover the footplate. If cholesteatoma matrix covers the footplate or the fractured footplate falls into the vestibule, removal of the footplate may be necessary. After stapedectomy during surgery with inflammation, there is high risk of severe sensorineural hearing loss even if the oval window is covered with fascia.

13.8 Tear in the Tympanic Membrane

Unintentional perforation of the tympanic membrane occurs during elevation of the tympanomeatal flap, especially in the second-stage surgery with scarred and/or retracted posterior quadrants. Very small tear can be managed by simple approximation of the perforation edges by placement of Gelfoam medial to the perforation. Larger perforations can be easily fixed with either the temporalis fascia or a piece of perichondrium placed underlay and supported medially by Gelfoam. Care should be taken not to leave the perforation edge inverted.

13.9 Tear in the Meatal Skin

Tear in the posterior meatal skin usually does not require any special management other than correct replacement. Edge of the tear should be approximated without any crease medially to avoid iatrogenic cholesteatoma.

Beginners may totally destroy the meatal skin flap during canaloplasty, usually with a cutting burr. The skin can be replaced on the canal wall if it remains in good shape. If the anterior meatal skin is lost completely, the anterior wall should be covered with a split-thickness skin graft taken from the edge of retroauricular incision to avoid postoperative canal stenosis.

13.10 Facial Nerve Injury

Injury to the facial nerve is one of the most serious surgical complications in middle ear surgery. Facial nerve palsy may occur during or after surgery for various causes. It is important to notice the palsy just after onset for deciding the option to be taken. One of the apparent advantages for the local anesthesia is capability to assess facial nerve function during and just after surgery.

13.10.1 Site of Injury

The location of the injury depends on the type of surgery being performed. In cases of mastoidectomy, the commonest site of injury is around the second genu of the nerve. Injury of the lateral semicircular canal is frequently associated with this due to its proximity to the nerve. Other less common site of injury after mastoid surgery includes the lower end of the mastoid segment near the digastric ridge. This occurs while the surgeon is trying to identify the digastric ridge, or while following the retrofacial cells in a constricted mastoid cavity using a burr larger than the required one. The tympanic segment can be injured during dissection of a cholesteatoma or some granulation tissue over the facial nerve without recognizing dehiscence of the fallopian canal. During canaloplasty, the lower portion of the mastoid segment of the nerve may in danger, since the nerve may course lateral to the fibrous annulus in the posteroinferior meatal wall. Rarely, anomalous facial nerve course can be encountered. It may occur at any level of the nerve, and the nerve may mimic mucosal fold or granulation tissue. The surgeon should be cautious when the patient has congenital malformations in the head and external ear areas. Preoperative computed tomography (CT) is useful to avoid such mistake, and intraoperative facial nerve monitoring helps if there is any doubt even after CT.

13.10.2 Decision Making

The movement of the face should be evaluated as soon as possible after all cholesteatoma surgeries because the management of the facial nerve injury highly depends on its time of onset. The anesthetic solution injected or applied during the surgery may cause transient facial weakness. The situation may confuse the surgeon especially after managing difficult operating field. This situation can be suspected when the weakness is less than complete and affects all branches of the nerve. A few hours of observation are enough to resolve the situation.

Whenever the surgeon recognizes facial nerve palsy during operation, any procedure must be stopped immediately and the operating field should be carefully inspected with intensive lavage. If the patient shows facial palsy immediately after surgery, two possibilities are concerned. One is unrecognized facial nerve injury, and the other is transient paralysis due to infiltration of local anesthesia. If no improvement is observed after a few hours, therapeutic option ranged from conservative treatment to revision surgery depending on the grade of the facial nerve function and procedures performed in the surgery. If the palsy is only partial or the surgeon is very confident of not having injured the nerve, conservative treatment is the choice. If the palsy is severe and there is any doubt, exploratory surgery within a day is indicated. High-resolution CT is helpful to speculate probable site of injury.

It should be stressed that multiple lesion can sometimes be found, so the exploration of the facial nerve should not stop until all the segments included in the original surgery are adequately visualized. If exploration reveals no damage or only edema, conservative management is the choice. If loss of the nerve is less than one-third of its thickness, conservative management by simple approximation of the damaged fibers or grafting of split-thickness nerve graft is the choice. Loss of more than one-third of its thickness is better managed by resection of the damaged segment followed by reconstruction using either end-to-end anastomosis, if possible, or nerve grafting. We prefer to use the sural nerve as a grafting material, since it can be obtained out of the ongoing surgical field, and the surgeon can continue to work in the ear. Benefit of the great auricular nerve is that it can be obtained in the same operative site with the same outcome as the sural nerve. This might be more convenient if there is no assistant. If interruption occurs in either the tympanic or the mastoid segment, both ends of the nerve should be refreshed with a sharp Beaver blade before grafting. For that sake, the two ends may be further exposed with a large diamond burr and a fine pick. The graft is placed between two ends with careful approximation. The fallopian canal serves as an ideal bed for the nerve grafting. Interruptions reaching the labyrinthine segment are often associated with opening of the labyrinth, and hearing preservation is not feasible. In such cases, the cochlea is drilled to expose the labyrinthine segment sufficiently. A groove created in the basal turn of the cochlea can be used as a bed for the grafted nerve (►Fig. 13.1a–c). If hearing preservation is necessary, the middle fossa approach is used instead. Fibrin glue is applied to fix the graft to both ends. In cases of facial nerve grafting, the best result falls into House–Brackmann Grade III at 1 year after surgery.

Delayed palsy may occur within a couple of days or even 8 to 10 days postoperatively. Pathogenesis of this delayed palsy is speculated to be reactivation of herpes virus or slow development of edema compressing the facial nerve. The situation can be managed conservatively with systemic steroids, and usually cause minor consequences.

We stress again that the surgeon should never be too arrogant to consult more experienced surgeon or even to ask for their help

in the intervention if there is any doubt of facial nerve damage. Avoidance of consultation can lead to further damage, either while waiting without action, or while exploring the wound. Revision surgery gets more difficult as time passes due to formation of granulation and fibrous tissue.

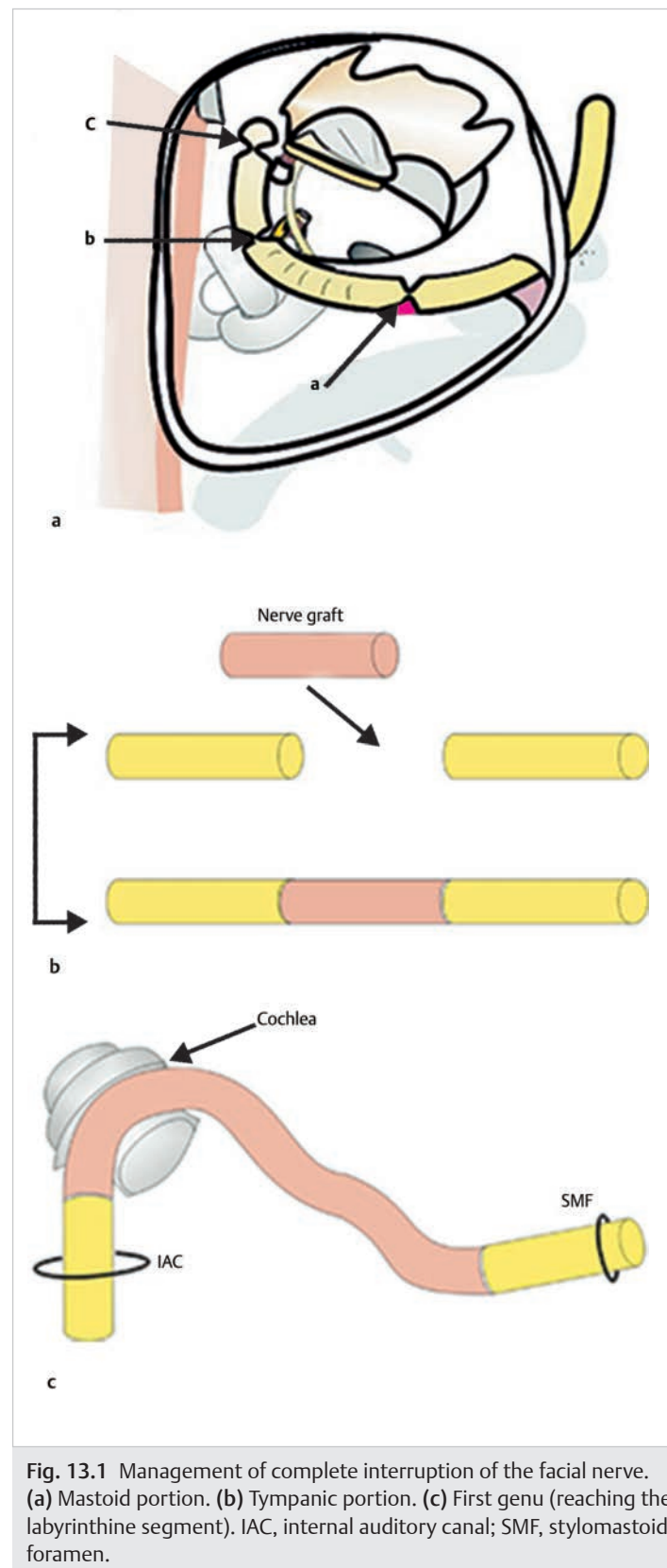


Fig. 13.1 Management of complete interruption of the facial nerve. (a) Mastoid portion. (b) Tympanic portion. (c) First genu (reaching the labyrinthine segment). IAC, internal auditory canal; SMF, stylomastoid foramen.

Case 13.1 (Right Ear)

See ► Fig. 13.2, ► Fig. 13.3, ► Fig. 13.4, ► Fig. 13.5, ► Fig. 13.6,
► Fig. 13.7, ► Fig. 13.8.

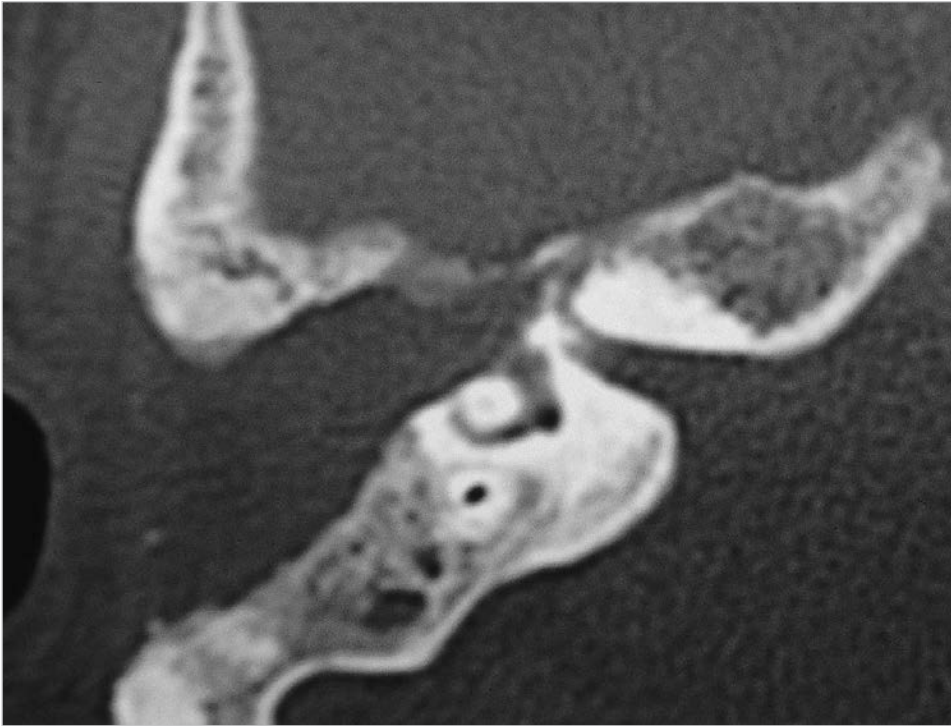


Fig. 13.2 The middle ear surgery performed elsewhere injured the facial nerve and damaged the labyrinth. The CT scan showed that the lateral semicircular canal, together with its ampulla, had been drilled. Injury to the tympanic segment of the nerve is anticipated. The scan also shows that removal of the mastoid air cells is not sufficient.

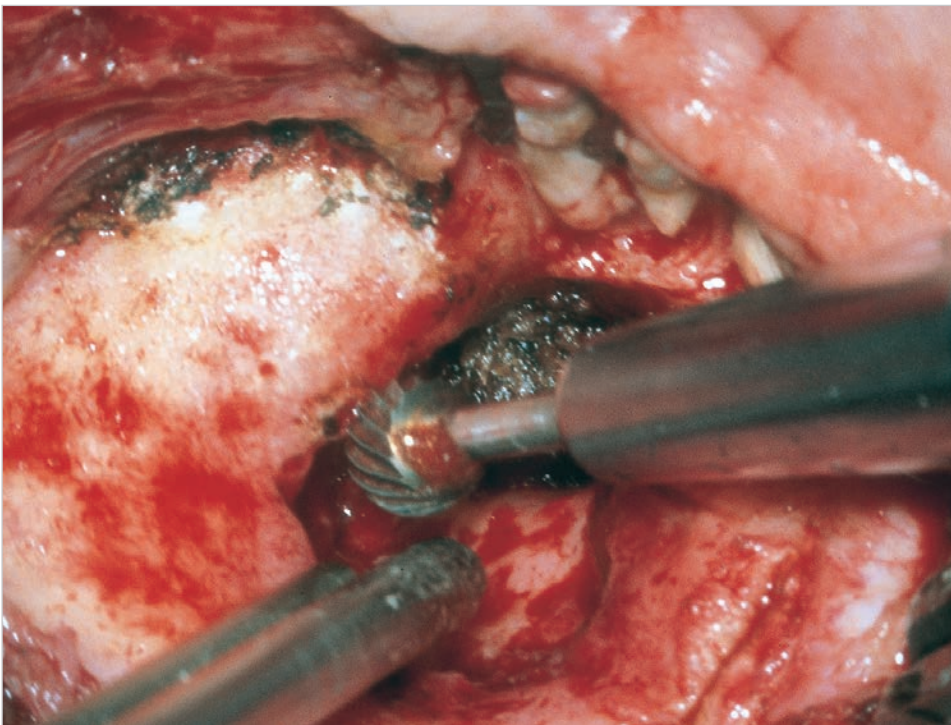


Fig. 13.3 Previous canal wall down tympanoplasty has been performed through a very narrow approach. Bony overhangs limiting access to the middle ear are removed.

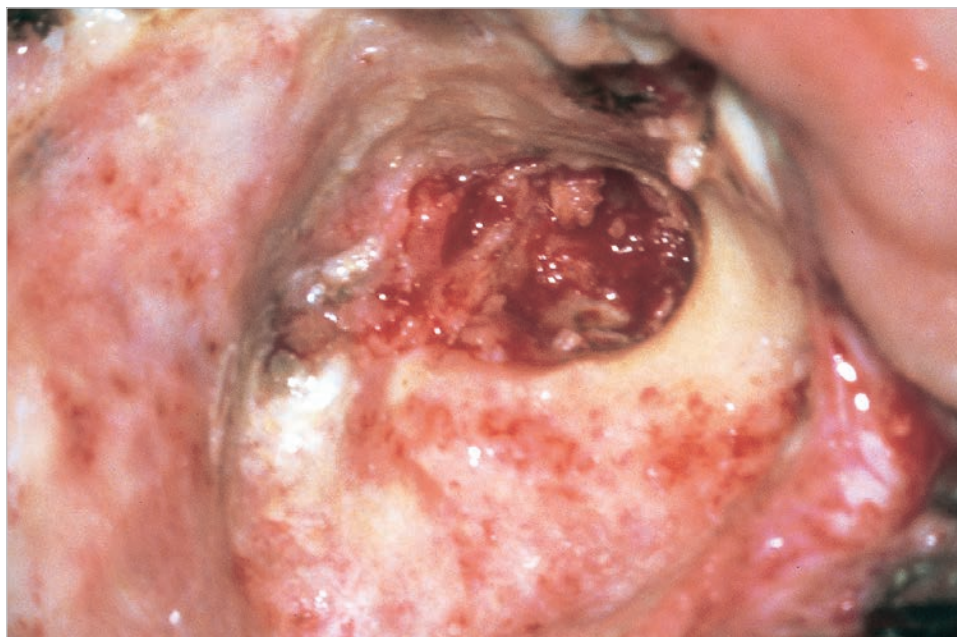


Fig. 13.4 The shape of the cavity is corrected. Structures that limit bone removal, the middle fossa dura superiorly and the sigmoid sinus posteriorly are skeletonized, and the cavity is saucerized.

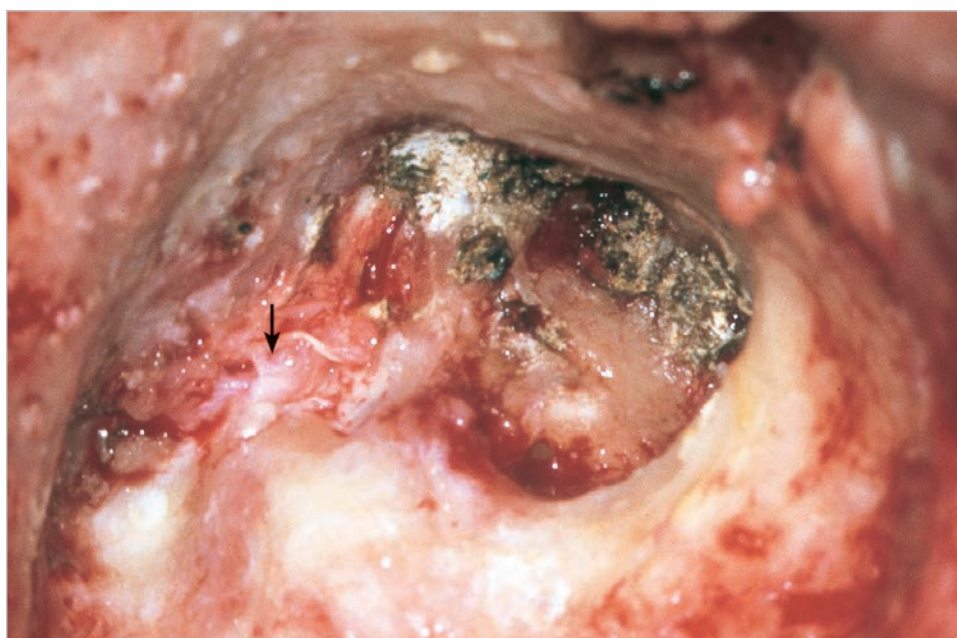


Fig. 13.5 Bony overhang protruding from the middle fossa plate limits the view to the attic. Superior half of the tympanic cavity, medial to the bony overhang, is filled with scar tissue. No facial nerve is found in this scar tissue, and the nerve is found to be interrupted in the tympanic segment. The opened ampulla of the lateral semicircular canal is seen (*arrow*). The mastoid segment of the nerve is skeletonized for the following reconstruction.



Fig. 13.6 The distal end of the facial nerve is detached from the bone and reflected posteriorly (*yellow arrow*). The scar tissue in the attic is cleaned, and the area is drilled. The insulated semicircular canals are indicated by black arrows.

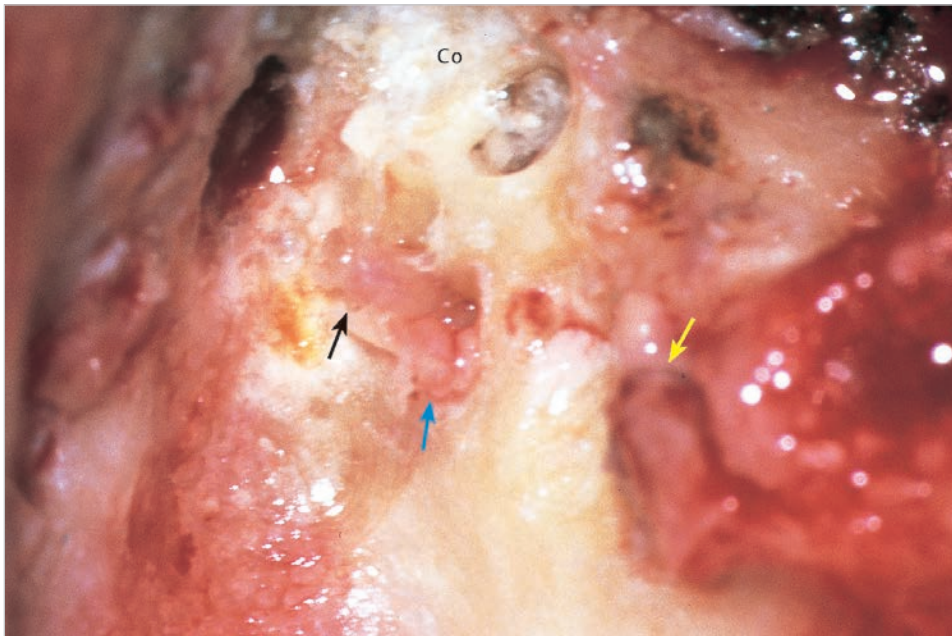


Fig. 13.7 The cochlea is drilled and the proximal end of the nerve is found in its labyrinthine segment (*black arrow*). Posteriorly, the superior and inferior vestibular nerves are seen (*blue arrow*). The distal end of the facial nerve is also seen (*yellow arrow*). Co, cochlea.

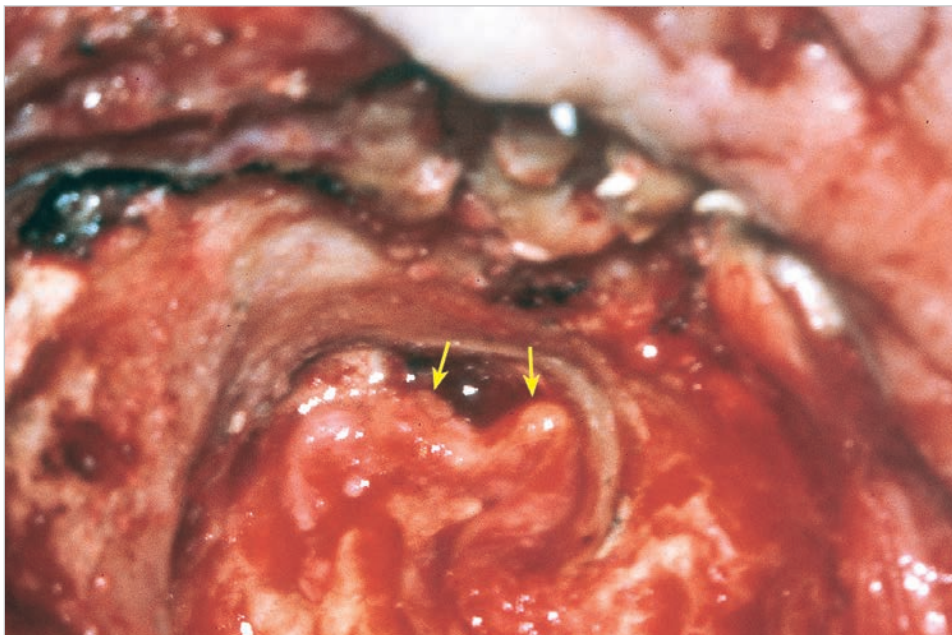


Fig. 13.8 The sural nerve (*yellow arrows*) is interposed between the two endings. The endings are fixed with fibrin glue.

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14 Petrous Bone Cholesteatoma

14.1 Feature of Petrous Bone Cholesteatomas and New Classification

Petrous bone cholesteatomas (PBCs) are slow-growing expansile epidermoid lesions arising in the petrous portion of the temporal bone with an incidence of 4 to 9% of all petrous pyramid lesions. These could be congenital, acquired, or iatrogenic. Congenital PBCs are most plausibly explained by the persistence of fetal epidermoid formation in the petrous bone or the middle ear from which it expands to the petrous bone. In such cases, the first symptoms are facial nerve paralysis, vertigo, and deaf ear due to invasion of the facial nerve and labyrinth. The acquired variety is due to the migration of squamous epithelium into the petrous bone as a result of advancement of middle ear cholesteatoma or secondary to a perforation in the tympanic membrane. The iatrogenic variety is due to the implantation of cholesteatoma after an otologic surgery. Fetid otorrhea, progressive facial palsy, vertigo, and hearing loss of any type (conductive, sensorineural, mixed) are usually encountered in these patients. From the clinical point of view, the presentation and management of these lesions are the same, regardless of its origin.

Otосcopy may be irrelevant or only demonstrates pars flaccida perforation or an open mastoid cavity with evidence of suppurative discharge. A computed tomography (CT) scan and magnetic resonance imaging (MRI) are fundamental to evaluate the extension of the lesion and to determine the surgical management.

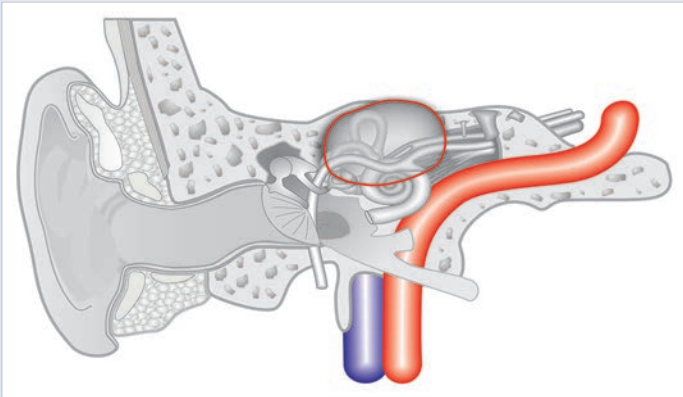
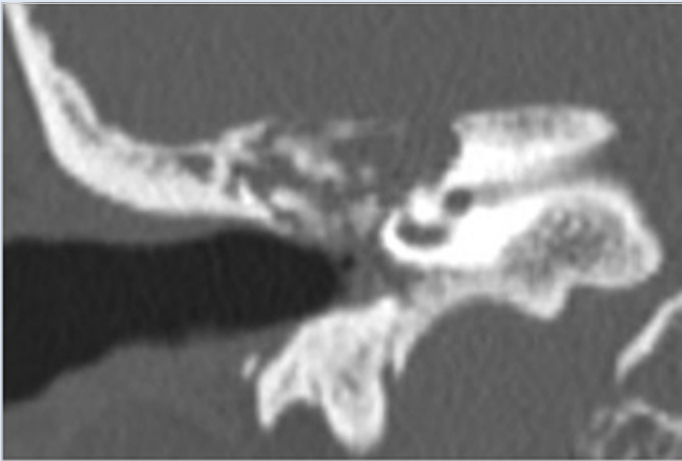
The rarity of these lesions, slow and silent growth pattern, their complex location in the skull base, proximity to vital neurovascular structures (facial nerve, internal carotid artery, sigmoid sinus, jugular bulb, lower cranial nerves, dura), and tendency to recur make PBCs very challenging to diagnose and treat. PBCs have shown to be locally aggressive by involving the petrous bone and

the areas surrounding it like the clivus, nasopharynx, sphenoid sinus, the infratemporal fossa, and even extending intradurally. Also, the close proximity of the disease to the labyrinth and the facial nerve risks both hearing and facial nerve function, which is reflected in the high incidence of facial nerve palsy (34.6–100%) seen in the important series reported in literature.

Surgery remains the mainstay of treatment of PBCs. The choice of surgical approach has evolved from radical petromastoid exenteration with marsupialization of the cavity to obliterative techniques following complete eradication. Advancements in neuroradiology and microscopic lateral skull base surgery have made it possible today to eradicate these lesions safely with minimal recurrences and perioperative morbidity. The primary objectives in surgical approaches for PBCs is to ensure total disease removal along with complete control and safety of the surrounding important neurovascular structures. The development of the transotic and transcochlear approaches, combined with various other skull base approaches, have helped to achieve both these objectives and are considered the mainstay of surgery for PBCs. Because of complex three-dimensional anatomy of the petrous bone, eradication of this pathology with minimal morbidity is difficult even for experienced surgeons. Surgeons should have ability to expose important structures that may cause life-threatening condition or severely reduce quality of life if damaged. Ability to manage cerebrospinal fluid (CSF) leak is mandatory. Therefore, the surgery is not in the category of middle ear surgery, but in the category of lateral skull base surgery, and the surgeon should be well prepared.

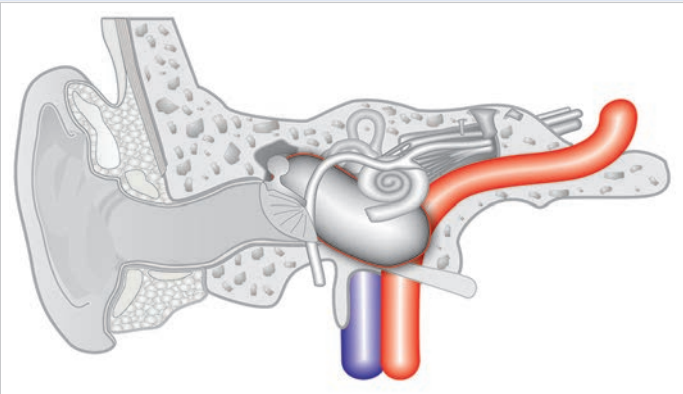
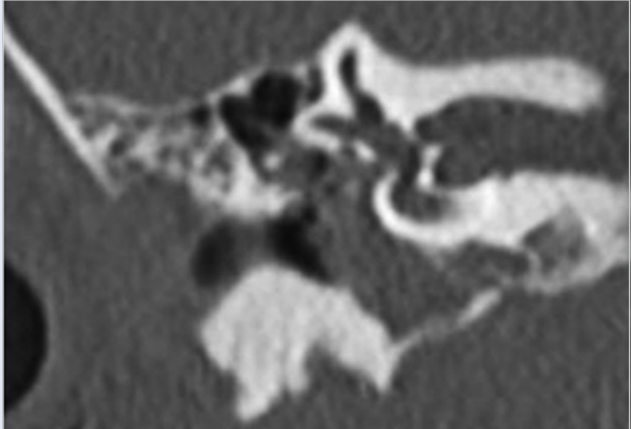
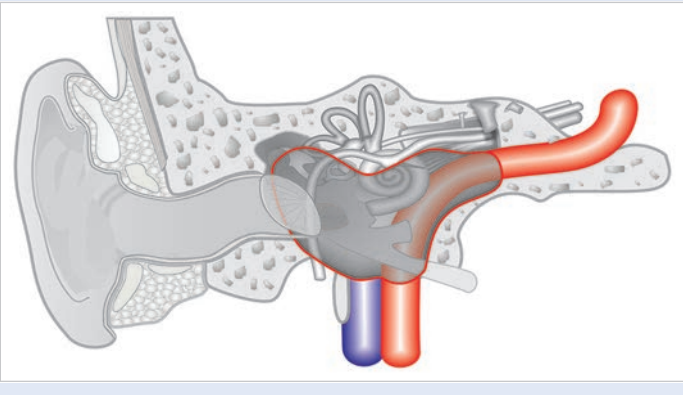
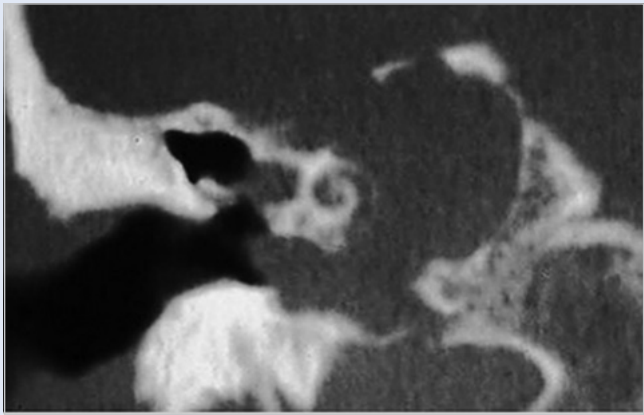
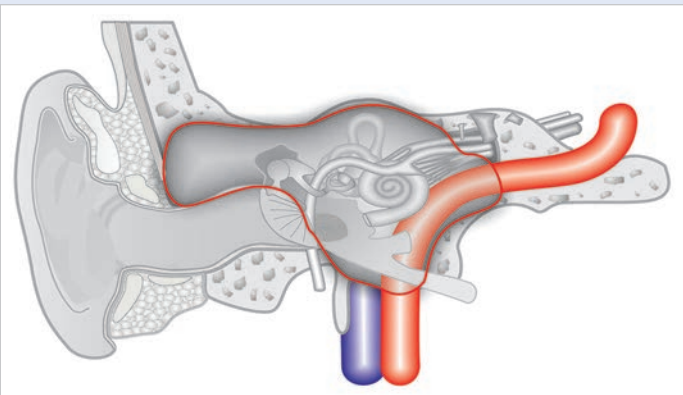
The classification proposed by Sanna divides PBCs into five groups based on the relationship of the disease to the labyrinthine block. This radiologic classification allows standardization in reporting and a clear planning of the surgical approach (► Table 14.1).

Table 14.1 Updated Sanna’s classification of petrous bone cholesteatoma

Class and features	Extension
Class I: Supralabyrinthine 	 Superior: Tegmen or dura. Inferior: SSCs, Co (apical turn). Medial: Limited extension beyond the otic capsule into PA. Lateral: Antrum, epitympanum, and further into ME. Anterior: Horizontal part of ICA. Posterior: SSCs, vestibule.

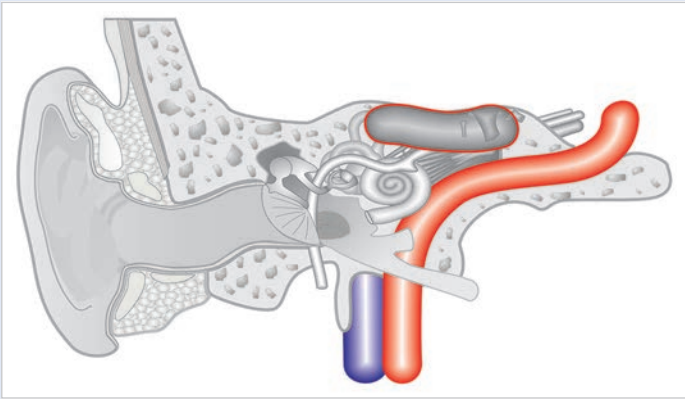
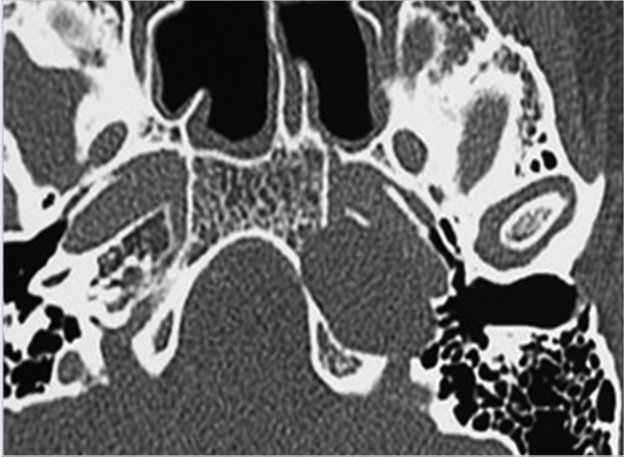
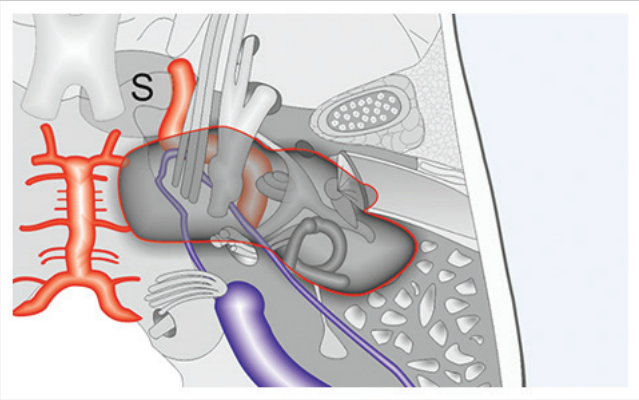
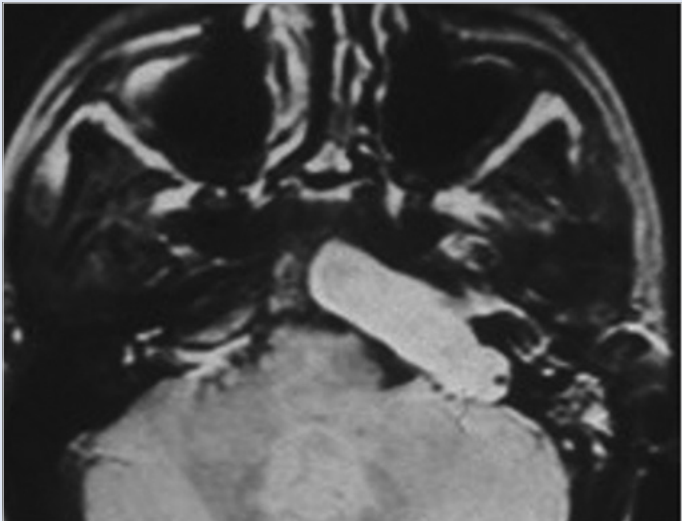
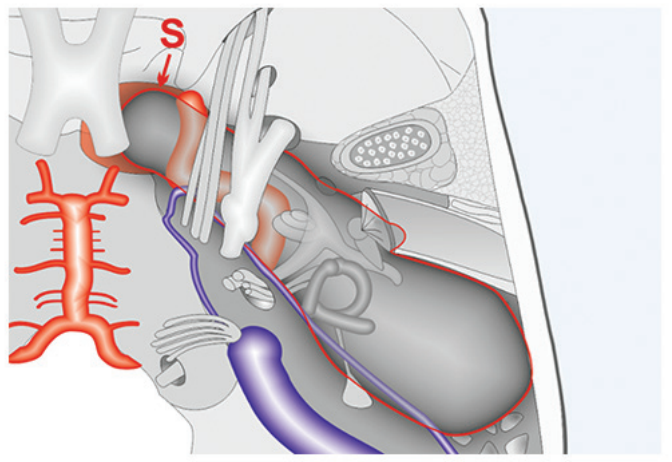
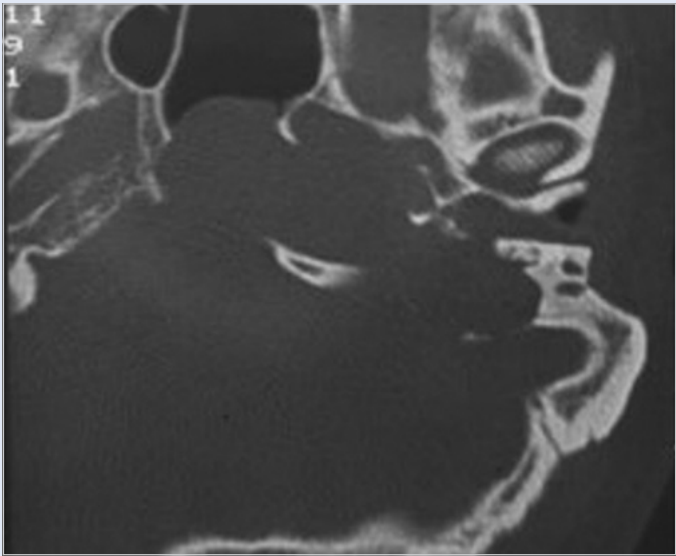
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Table 14.1 (Continued) Updated Sanna's classification of petrous bone cholesteatoma

Class and features	Extension
Class II: Infralabyrinthine  Centered on the infracochlear, infralabyrinthine and hypotympanic cells. Fistula of SSCs, erosion of Co, JB, carotid canal, involvement of LCNs.	 Superior: Basal turn of Co, vestibule. Inferior: JB, LCNs, occipital condyle. Medial: Limited extension beyond the otic capsule into PA. Lateral: Hypotympanum and further into ME, retrofacial cells. Anterior: Vertical and horizontal part of ICA. Posterior: SSCs and vestibule.
Class III: Infralabyrinthine—Apical  Involves infralabyrinthine cell tracts extending medially into the PA. Fistula of SSCs, erosion of Co, JB, involvement of LCNs, extensive destruction of the carotid canal, involvement of IAC.	 Superior: Basal turn of Co, vestibule, and may reach dura of MCF. Inferior: JB, LCNs, occipital condyle. Medial: extension into the PA, lower clivus, along the greater wing of sphenoid into the foramen spinosum, foramen ovale. May extend up to sphenoid sinus. Lateral: Hypotympanum and further into ME, retrofacial cells. Anterior: Vertical and horizontal part of ICA. Posterior: IAC, dura of PCF.
Class IV: Massive  Centered on the otic capsule. Various degrees of destruction of the otic capsule, involvement of FN.	 Superior: Dura of MCF, may extend intradurally. Inferior: Hypotympanic cells, infralabyrinthine cells, JB, LCNs. Medial: Extension into the PA, lower clivus, along the greater wing of sphenoid into the foramen spinosum, foramen ovale. May extend up to sphenoid sinus. Lateral: ME, antrum, retrofacial cells. Anterior: Vertical and horizontal part of ICA. Posterior: IAC, dura of PCF, may extend intradurally.

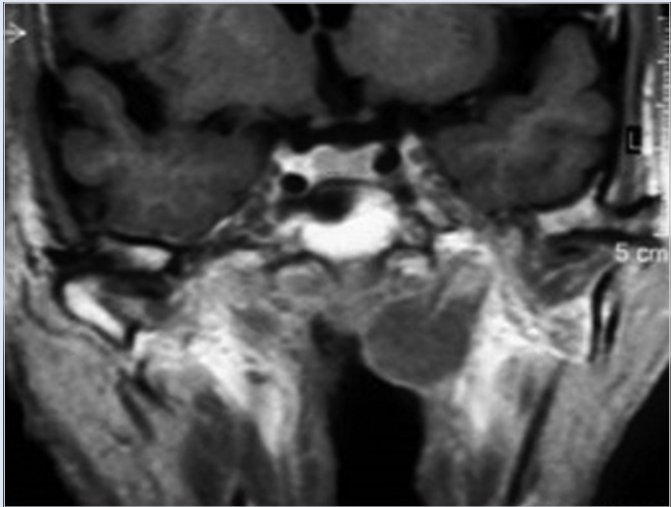
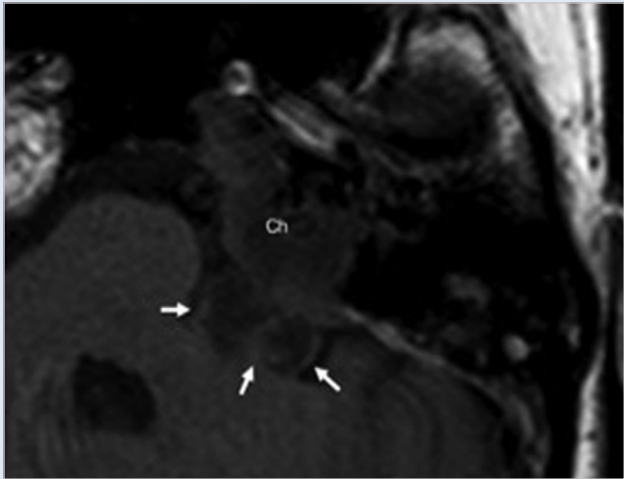
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Table 14.1 (Continued) Updated Sanna’s classification of petrous bone cholesteatoma

Class and features	Extension
Class V: Apical 	 Centered on PA. Otic capsule may be eroded medially, erosion of horizontal petrous carotid, clivus, and intradural extensions into MCF and PCF. Extensions also possible into sphenoid, nasopharynx, or infratemporal fossa. Superior: Dura of MCF, Meckel’s cave, may extend intradurally. Inferior: Hypotympanic cells, infralabyrinthine cells, JB, LCNs, infratemporal fossa. Medial: Extension into the sphenopetroclival junction, midclivus, along the greater wing of sphenoid into the foramen spinosum, foramen ovale. May extend up to sphenoid sinus. Lateral: Otic capsule. Anterior: Horizontal part of ICA and foramen lacerum. Posterior: IAC, dura of PCF, may extend intradurally.
Subclass and features	Radiologic example
Clivus (C) 	
Sphenoid sinus (S) 	

(Continued)

Table 14.1 Updated Sanna’s classification of petrous bone cholesteatoma

Subclass and features	Radiologic example
Nasopharynx (N)	
It is the rarest extension of the PBC. It is an extension of infralabyrinthine–apical or massive PBCs, which may extend through the clivus beneath the sphenoid sinus into the nasopharynx.	
Intradural (I)	
Intradural extensions may arise from the massive, infralabyrinthine–apical, and apical PBCs usually into the posterior cranial fossa and rarely into the middle cranial fossa.	
Abbreviations: Co, cochlea; FN, facial nerve; IAC, internal auditory canal; ICA, internal carotid artery; JB, jugular bulb; LCNs, lower cranial nerves; MCF, middle cranial fossa; ME, middle ear; PA, petrous apex; PBC, petrous bone cholesteatoma; PCF, posterior cranial fossa; SSCs, semicircular canals.	

14.2 Current Therapeutic Result

From 1980 to 2015, we treated 240 cases of PBC that comprises 3.3% of 7,270 cholesteatomas surgically treated in Gruppo Otologico in that period. Nearly half of PBCs (46%) are classified as the supralabyrinthine type, and the massive is the second most common type (►Table 14.2). Ethiotogically, 65% of 240 cases seemed to be congenital, 11% acquired, and 24% were attributed to either recurrence or iatrogenic. The approach used in the surgery is shown in ►Table 14.3. Transotic approach removing both the cochlea and the posterior labyrinth leaving the facial nerve in situ is the approach most frequently used, and modified transcochlear approach mobilizing the facial nerve posteriorly and removing the entire labyrinth comes second. The enlarged translabyrinthine approach is used to remove cholesteatoma mainly located posteriorly. The middle fossa approach is rarely used but may be applied to the small supralabyrinthine cholesteatoma in which hearing preservation is of primary concern. In anteriorly located petrous bone cholesteatoma involving the anterior aspect of the horizontal segment of the internal carotid artery and cases with necessity of controlling the area of clivus and sphenoid, dislocation of the temporomandibular joint with drilling of the greater wing of the sphenoid bone is required. In such cases, the infratemporal fossa approach type B is applied, or combined with other approaches. By experienced hand, total removal of the disease can be achieved with very low morbidity (►Table 14.4).

Table 14.2 Percentage of classified 240 PBCs operated in Gruppo Otologico from 1980 to 2015

Type	%
Supralabyrinthine	46
Massive	36
Infralabyrinthine	9
Infralabyrinthine–apical	7
Apical	2

Table 14.3 Approach applied to PBC removal in Gruppo Otologico from 1980 to 2015 (240 cases in total)

Approach	%
Transotic	32
Modified transcochlear	28
Enlarged translabyrinthine	18
Subtotal petrosectomy	13
Middle fossa	2
Other (infratemporal fossa A/B)	7

Table 14.4 Complications after 240 PBC removal in Gruppo Otologico from 1980 to 2015

Complication	Case	%
Recurrence	7	3.6
Cavity infection	2	0.8
CSF leak	1	0.4
Brain abscess	1	0.4
LCN deficit (temporary)	1	0.4
Abdominal hematoma	1	0.4

Abbreviations: CSF, cerebrospinal fluid; LCN, lower cranial nerve.

14.3 Decision Making in PBCs

Decision making is the crucial aspect of surgical management. It depends on several factors, the most significant of which are the extent of the disease and preoperative facial nerve function. The approach is mainly chosen depending on the location of PBC, which should be determined according to the CT scan and MRI findings. The classification of PBC proposed by us is of paramount importance as it gives information regarding the anatomical position and the extent of the disease. The subclassification proposed aims at preoperatively diagnosing the extension of PBC beyond the temporal bone (clivus, sphenoid sinus, nasopharynx, intradural space). This helps to plan the surgical approach, which is important to clear the disease from these areas.

The main factors to be taken into consideration while treating these lesions are as follows: (1) complete eradication of the disease, (2) preservation of facial nerve function, (3) prevention of CSF leak and meningitis, (4) cavity obliteration, and (5) hearing preservation whenever feasible.

In supralabyrinthine PBC (► Fig. 14.1), if hearing is normal without any evidence of a fistula in the basal turn of the cochlea, we prefer a middle fossa approach which may be combined with a transmastoid approach depending on the extension of the disease. In the presence of sensorineural hearing loss or evidence of a fistula in the basal turn of the cochlea we prefer a radical approach (subtotal petrosectomy/enlarged translabrynthine approach/transotic approach) with cavity obliteration.

In infralabyrinthine PBC (► Fig. 14.2), bone conduction can be preserved with subtotal petrosectomy and blind sac closure of the external auditory canal with cavity obliteration. Hearing preservation is usually not possible in infralabyrinthine–apical and massive PBC (► Fig. 14.3), hence we use a transotic approach or a modified transcochlear approach type A depending on preoperative facial nerve function. Modified transcochlear approaches provide excellent access to the petrous apex, clivus, sphenoid sinus, nasopharynx, and intradural space depending on the type used. The posterior rerouting of the facial nerve gives excellent access to the petrous apex and good control of the medial aspect of the facial nerve but carries the disadvantage of postoperative facial paralysis. Therefore, we prefer a transotic approach when facial nerve function is normal. Whenever the cholesteatoma involves the apical portion of the temporal bone (► Fig. 14.4) or when it extends further to the clivus, sphenoid sinus, or nasopharynx, an infratemporal fossa approach type B is incorporated into the transotic approach or modified transcochlear approach type A depending on the preoperative status of the facial nerve.

In cases of PBC involving the only hearing ear, we usually follow up the patient closely. If the condition shows continuous progression, an operation is planned in which the lesion is removed, and a cochlear implant is inserted simultaneously whenever possible. The particular type of operation to be performed depends on the class of the PBC.

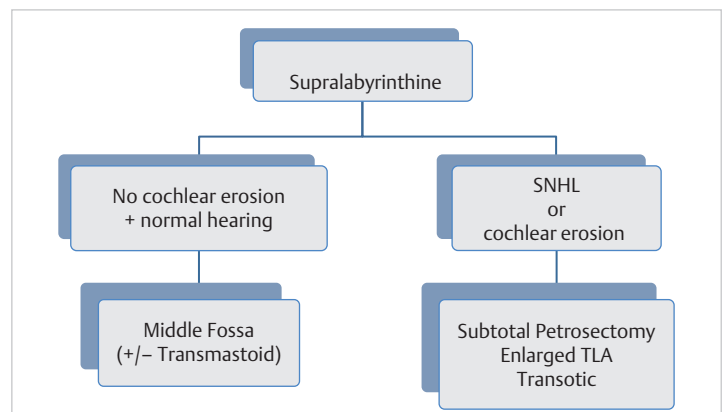


Fig. 14.1 Surgical strategy of supralabyrinthine PBCs.

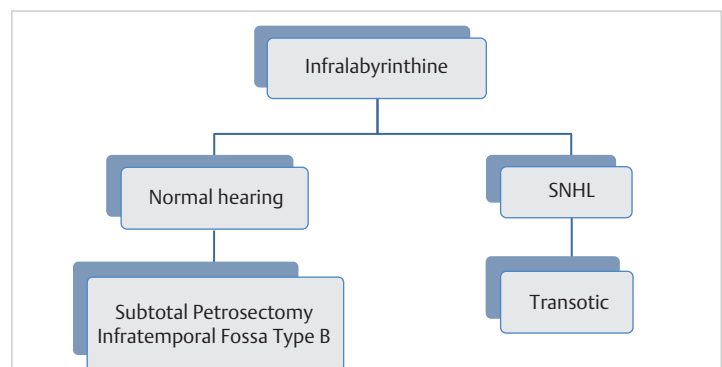


Fig. 14.2 Surgical strategy of infralabyrinthine PBCs.

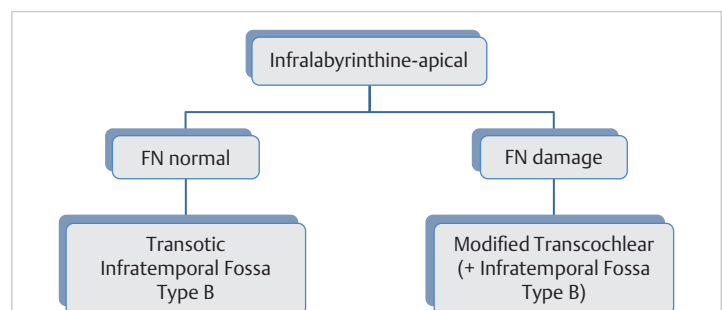


Fig. 14.3 Surgical strategy of infralabyrinthine–apical PBCs.

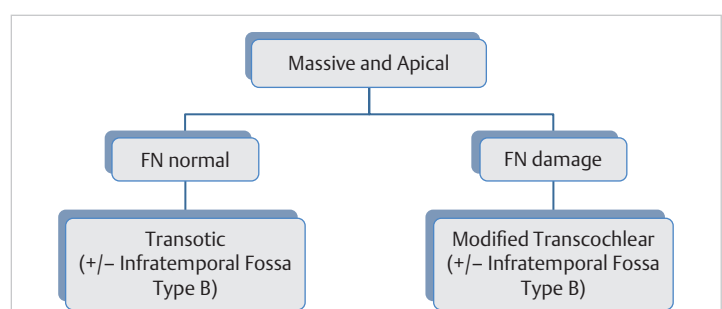


Fig. 14.4 Surgical strategy of massive and apical PBCs.

14.4 The Transotic and The Modified Transcochlear Approaches

The original transcochlear approach described by House and Hitselberger (1976) includes identification of the internal auditory canal, posterior rerouting of the facial nerve, and removal of the cochlea and petrous apex with preservation of the middle ear and external auditory canal. Fisch (1978) described the transotic approach in which he removed the external auditory canal and middle ear but keeps the facial nerve in situ (► Fig. 14.5).

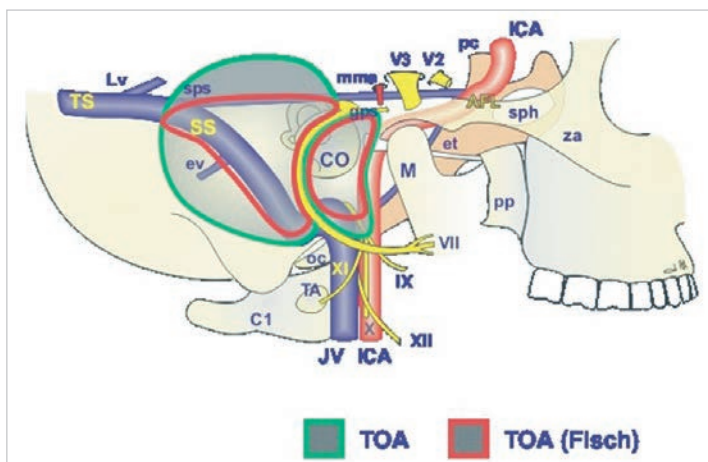


Fig. 14.5 A schematic drawing showing the outlines of the transotic approach. C1, first cervical vertebra; CO, cochlea; ET, eustachian tube; EV, emissary vein; FN, facial nerve; IAC, internal auditory canal; ICA, internal carotid artery; JV, jugular vein; IX, glossopharyngeal nerve; Lv, Labbe's vein; M, mandible; MMA, middle meningeal artery; OC, occipital condyle; pc, posterior clinoid; pp, pterygoid process; SPH, sphenoid; SS, sigmoid sinus; TA, transverse process of the atlas; TS, transverse sinus; V2, second branch of the trigeminal nerve; V3, third branch of the trigeminal nerve; VII, facial nerve; XI, accessory nerve; XII, hypoglossal nerve; ZA, zygomatic process.

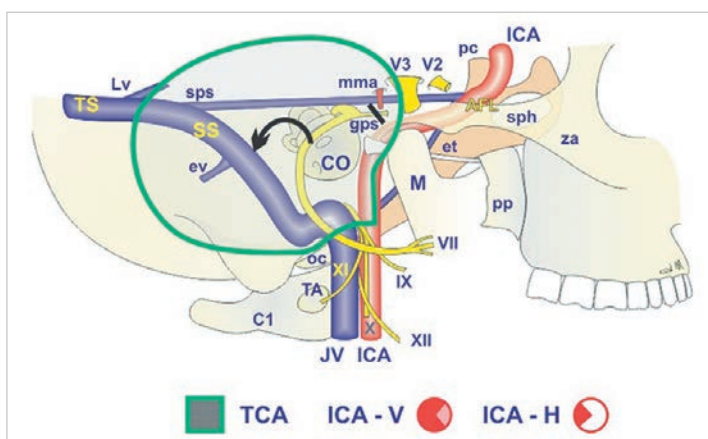


Fig. 14.6 A schematic drawing showing the outlines of the modified transcochlear approach type A. About three-fourths of the vertical internal carotid artery (ICA-V) is under control in contrast to only one-fourth of the horizontal internal carotid artery (ICA-H) using this approach. C1, first cervical vertebra; CO, cochlea; ET, eustachian tube; EV, emissary vein; FN, facial nerve; IAC, internal auditory canal; ICA, internal carotid artery; JV, jugular vein; IX, glossopharyngeal nerve; Lv, Labbe's vein; M, mandible; MMA, middle meningeal artery; OC, occipital condyle; pc, posterior clinoid; pp, pterygoid process; SPH, sphenoid; SPS, sphenoid sinus; SS, sigmoid sinus; TA, transverse process of the atlas; TS, transverse sinus; V2, second branch of the trigeminal nerve; V3, third branch of the trigeminal nerve; VII, facial nerve; XI, accessory nerve; XII, hypoglossal nerve; ZA, zygomatic process.

Our modified transcochlear approach (► Fig. 14.6), on the other hand, combines the removal of the external auditory canal and middle ear with the posterior rerouting of the facial nerve, thus removing the major impediment to anterior extension of the approach. This allows better control of the vertical and horizontal intrapetrous internal carotid artery and facilitates the total removal of the petrous apex. The extensive anterior bone removal provides an excellent control of the ventral surface of the brainstem without cerebellar and brainstem retraction. The surgical procedures required in both approaches, and other approaches required for PBC removal are described in detail in our former publications (see *Atlas of Microsurgery of the Lateral Skull Base* 2nd ed, Thieme 2008; see also *The Facial Nerve in Temporal Bone and Lateral Skull Base Microsurgery*, Thieme 2006).

14.5 Problems and Solutions in PBC Surgery

14.5.1 Hearing Preservation

Because of their aggressive nature and difficulty of revision surgery, total removal of the disease is of primary concern in the majority of PBCs. Hearing preservation would be important in exceptional cases, that is, bilateral PBCs or in a PBC of the only hearing ear. However, in the era of Bone-Conducted Hearing Implants, Cochlear Implants, and Vibrant Soundbridge even these cases can be treated successfully with hearing rehabilitation. If the cochlea is not destroyed beyond what is essential for the clearance of the disease, a cochlear implant should be used in ears with an accessible cochlear lumen even after labyrinthectomy. Another option is a BAHA if bone conduction is preserved in the ipsilateral ear.

14.5.2 Facial Nerve

Facial nerve lesions may vary from simple erosion of the fallopian canal to total interruption of the nerve with fibrous tissue interposition. Management depends on three principal factors: preoperative facial nerve function, degree of facial nerve involvement, and duration of facial nerve dysfunction. In cases where the preoperative facial nerve function is good, or onset of the facial nerve palsy is a few weeks before, a surgeon can be optimistic about a favorable facial nerve outcome as far as the continuity of the facial nerve is preserved during the surgery.

- **Decompression.** If there is a compression of the nerve with preserved anatomical integrity, then decompression of the nerve should be performed.
- **Rerouting.** When the lesion is present medial to the facial nerve and complete control over the lesion is hampered due to the position of the nerve, then rerouting of the facial nerve, either partial or total, is considered.
- **End-to-end anastomosis.** If there is a discontinuity of the nerve or a fibrous tissue interposition, the affected segment should be excised, and a tension-free end-to-end anastomosis is performed.
- **Nerve grafting.** Whenever the nerve segment lost is long and a tension-free end-to-end anastomosis is not possible, continuity of the nerve is reestablished using a nerve graft. We prefer a sural nerve for grafting purposes.
- **Facial-hypoglossal or facial-trigeminal (masseteric nerve) anastomosis.** In patients with long duration of facial palsy (> 12 months).

14.5.3 Internal Carotid Artery

The PBC may involve the internal carotid artery in the vertical and/or the horizontal parts. In this situation, a complete control over the artery is important prior to attempting its removal. A modified transcochlear approach type A/transotic approach is used for involvement of the vessel in the vertical part, whereas an infratemporal fossa type B/modified transcochlear approach type B is used for involvement of vertical and horizontal parts. In case of a lesion extending into the petrous apex, clivus, sphenoid sinus, and rhinopharynx, it is important to perform a complete control of the internal carotid artery in order to mobilize the artery if necessary. PBCs are less aggressive in terms of arterial involvement and are easier to dissect as compared to other tumors (e.g., tympanojugular paragangliomas). The internal carotid artery has a thick adventitia, which tolerates the dissection maneuver of the matrix. However, it requires extreme caution and surgical skill to achieve complete removal of the matrix.

14.5.4 Sigmoid Sinus and Jugular Bulb

Dealing with the jugular bulb in cases where it is involved is a well-thought-out strategy. Preoperative imaging must be carefully analyzed for two aspects: the relationship of the lesion with the jugular bulb and the patency of the contralateral venous drainage system by MR venography. In the presence of a hypoplasia of the contralateral venous system, sacrifice of the bulb means occlusion of the main venous drainage of the brain, with the consequent risk of benign intracranial hypertension or venous infarction of the temporal lobe. In such cases, damage to the jugular bulb or the sigmoid sinus must be avoided at all cost. The involvement of the sigmoid sinus and the jugular bulb presents a problem in matrix removal due to the thin wall and the fragility of these structures. In such cases, it is important to control the internal jugular vein in the neck prior to the dissection of the matrix. The ligation of the internal jugular vein in the neck and the sigmoid sinus packing (extraluminal and intraluminal) enables removal of the lateral wall of the dome of the jugular bulb and the sigmoid sinus to clear the matrix in the rare cases of accidental opening of the bulb. This maneuver also helps in preserving the cranial nerves IX, X, and XI. During this procedure bleeding from the inferior petrosal sinus is controlled with Surgicel packing. In cases where its involvement is suspected, it is always advisable to ensure preoperatively the patency of the contralateral cerebral vein.

14.5.5 Dura

The matrix is often adherent to the dura of the middle and posterior fossa. Bipolar coagulation of all the suspected portions of the dura mater is performed to destroy all the possible remnants of the matrix. We have been using bipolar coagulation in all cases to devitalize the epithelium, and other authors who have used the same technique also agree with us. Bipolarizing large areas of the dura does not lead to any dural necrosis if carefully performed. On the other hand, use of monopolar cautery on the dura may penetrate the dura, and is strictly prohibited. Long-term follow-up has shown that bipolar coagulation of the dura is safe and adequate for complete control.

14.5.6 Cerebrospinal Fluid Leak

There is a risk of opening the dura during removal of the adherent matrix and drilling of the thin bony plate causing an intraoperative CSF leak. CSF leaks resulting from dural tears do not need special repair but can be swiftly managed by inserting free muscle plugs into the subarachnoid space through the defect and cavity obliteration with fat. In case of CSF leak from the internal auditory canal, excessive packing of the canal with some tissue may result in compression of the facial nerve. The condition can be treated by adopting a translabyrinthine approach.

14.5.7 Examination of Hidden Areas

Once the removal of the disease has been achieved, it is useful to carry out an endoscopic examination of the cavity with a 30-degree rigid endoscope to visualize the hidden areas that might not be accessible to the microscope. In some cases, epithelium missed by the conventional technique can be found on endoscopic examination. In our experience, as far as the approach is appropriate, this technique is rarely required.

14.5.8 Residual Lesions or Recurrences

After complete eradication of the disease, it is mandatory to obliterate the cavities with autologous abdominal fat. The major disadvantage of cavity obliteration is that the recurrence cannot be directly visualized and detected. Therefore, radiologic follow up with a high-resolution CT scan and a cerebral MRI (T1-, T2-weighted images with fat suppression, diffusion-weighted images non-EPI) with gadolinium enhancement every year for at least 10 years is required.

14.6 Surgical Anatomy for PBC Surgery

During surgery of PBCs, the surgeon should manage deep vital structures such as the carotid artery, the jugular bulb, the internal auditory canal, and cranial nerves in and around the petrous bone. These structures are usually covered with thick bone, and pathologic tissue may distort their original position. The approach to the operative site gets narrower in accordance with its depth and widening of that approach for eradication of cholesteatoma without risking vital structures requires solid knowledge of three-dimensional anatomy. In some cases of large PBCs, anatomical knowledge of both cerebellopontine (CP) angle and neck is required. Before stepping into the operating room, intensive work in dissection laboratory is indispensable.

14.6.1 Surgical Anatomy of the Translabyrinthine Approach

In the translabyrinthine approach, posterior labyrinth, including semicircular canals and the vestibule, is removed to access the area located medially to it, and posteriorly to the internal auditory canal. In cholesteatoma surgery, the approach is usually combined with removal of the posterior canal wall and blind-sac closure of the external auditory canal. It can be enlarged toward

the attic, and anteriorly to the internal auditory canal to some extent to reach the petrous apex. However, it does not afford access to deep area in the petrous apex. Main indication of this approach is supralabyrinthine petrous bone cholesteatomas with limited extension to the petrous apex. When the cholesteatoma

reaches the internal auditory canal, the bone covering the middle fossa dura and the sigmoid sinus including retrosigmoid area should be removed completely to maximize this approach. Refer to ► Fig. 14.7, ► Fig. 14.8, ► Fig. 14.9, ► Fig. 14.10, ► Fig. 14.11, ► Fig. 14.12, ► Fig. 14.13, ► Fig. 14.14.

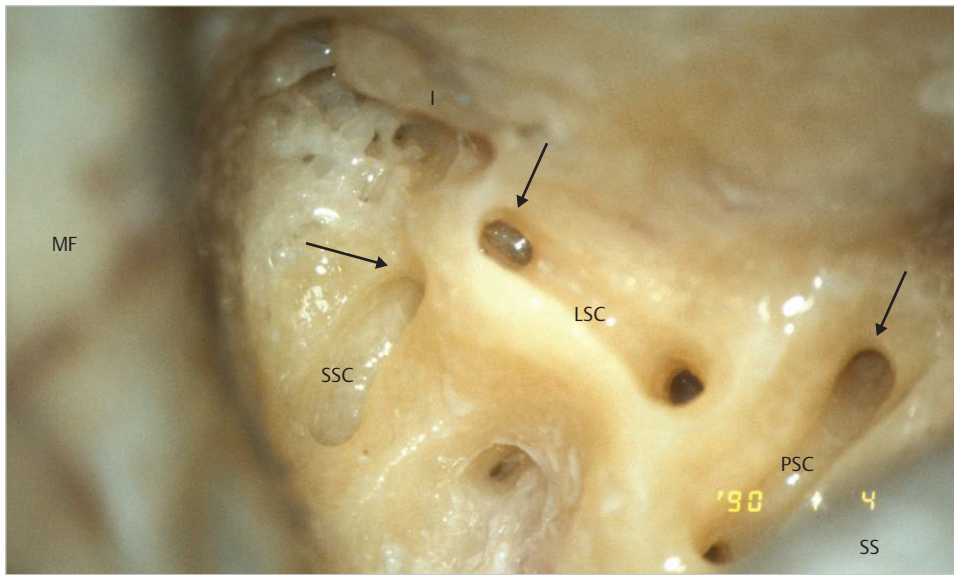


Fig. 14.7 Right ear. The semicircular canals are skeletonized and partially opened. Ampullae of canals are located on their most anterior parts (arrows). I, incus; LSC, lateral semicircular canal; MF, middle fossa dura; PSC, posterior semicircular canal; SS, sigmoid sinus; SSC, superior semicircular canal.

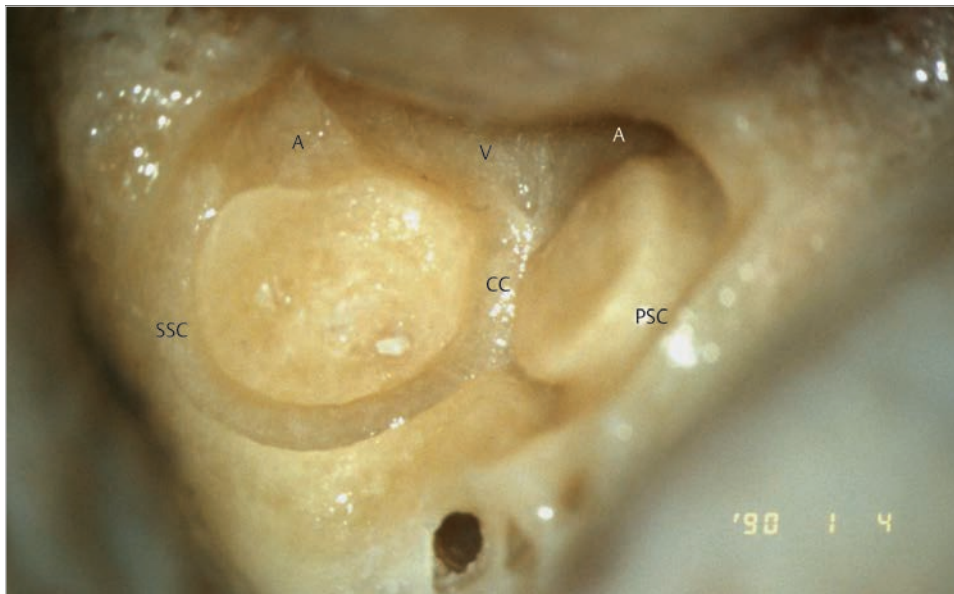


Fig. 14.8 The lateral semicircular canal is removed, and the vestibule is opened. The superior and the posterior semicircular canals join to make common crus. A, ampullae; cc, common crus; PSC, posterior semicircular canal; SSC, superior semicircular canal; V, vestibule.

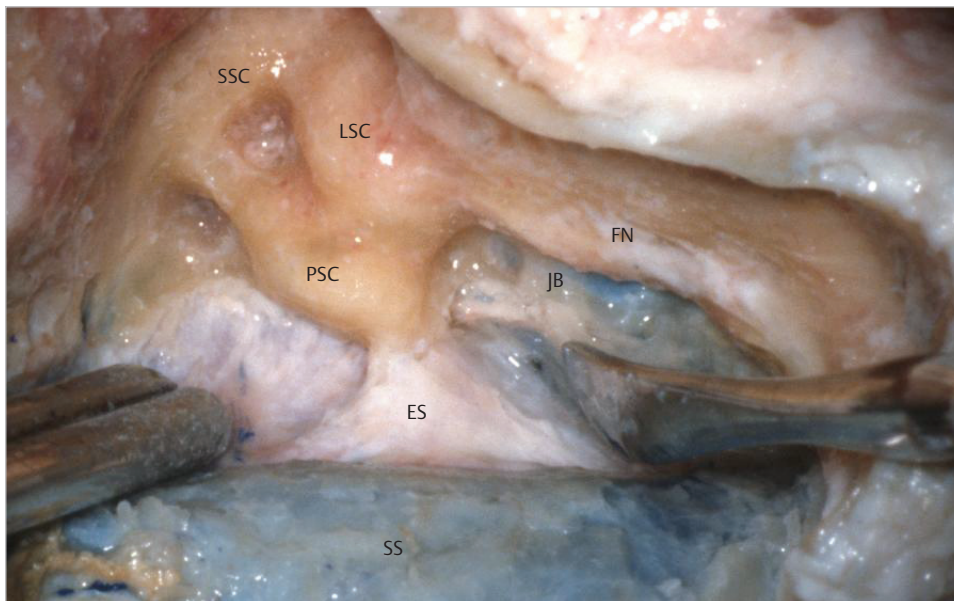


Fig. 14.9 The mastoid segment of the facial nerve is identified, and otic capsule of semicircular canals are skeletonized. The posterior fossa dura is exposed to identify the endolymphatic sac seen as a triangle thickening of connective tissue over the dura. ES, endolymphatic sac; FN, facial nerve; JB, jugular bulb; LSC, lateral semicircular canal; PSC, posterior semicircular canal; SS, sigmoid sinus; SSC, superior semicircular canal.

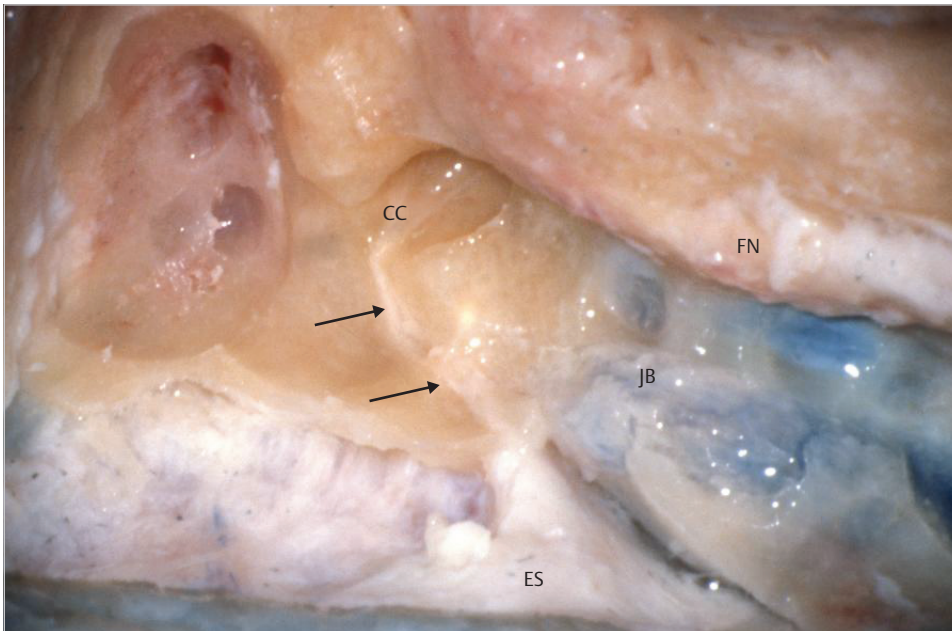


Fig. 14.10 The semicircular canals are removed to follow the vestibular aqueduct. The duct arising from the endolymphatic sac, leaving the posterior fossa dura to pass through the bone posteriorly to the posterior semicircular canal, and reaching the common crus is shown (arrows). CC, common crus; ES, endolymphatic sac; FN, facial nerve; JB, jugular bulb.

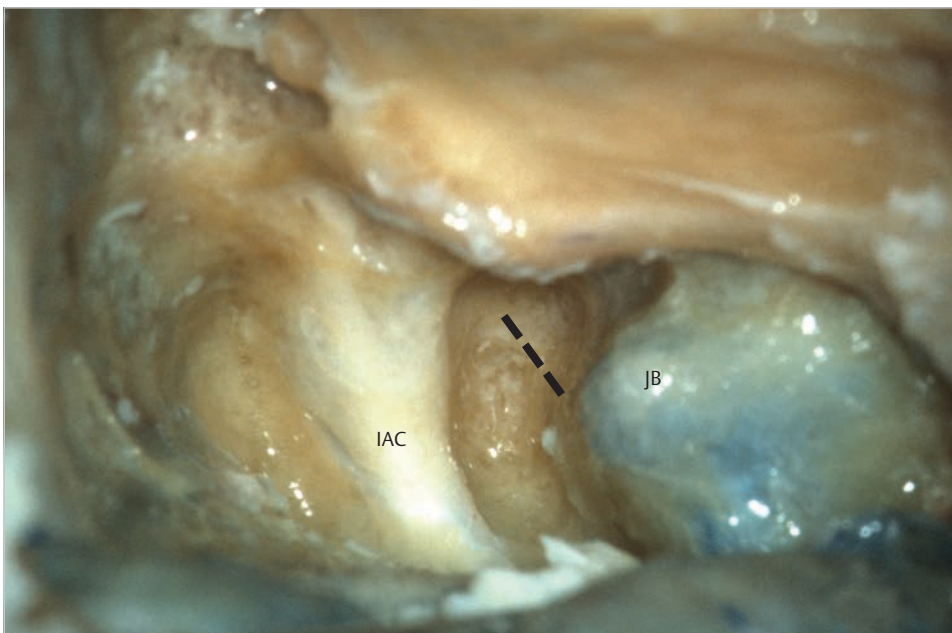


Fig. 14.11 The labyrinthectomy is completed, and the posterior face of the internal auditory canal is skeletonized. A bulge of the jugular bulb is located just inferiorly to it. The cochlear aqueduct runs from inferomedial to superomedial between anterior face of two structures (dotted line). Since the glossopharyngeal nerve runs just inferior to the aqueduct, it indicates inferior border of the drilling of this area. In patients, as far as it maintains patency, presence of the aqueduct can be identified by flowing out of CSF. IAC, internal auditory canal; JB, jugular bulb.

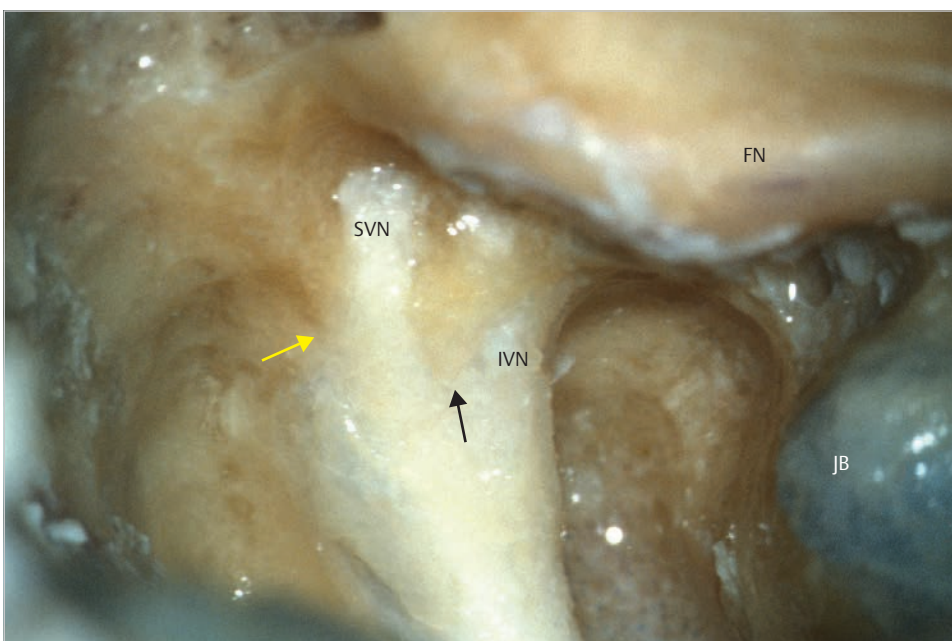


Fig. 14.12 The fundus of the internal auditory canal is divided into two, superiorly and inferiorly, by horizontal crest (arrow). In the posterior face of the internal auditory canal, the superior compartment is occupied by the superior vestibular nerve, and the inferior part, the inferior vestibular nerve. The superior part is further divided by the vertical crest (Bill's bur; yellow arrow). The facial nerve is located anteriorly to the vertical crest. FN, facial nerve; IVN, inferior vestibular nerve; JB, jugular bulb; SVN, superior vestibular nerve.

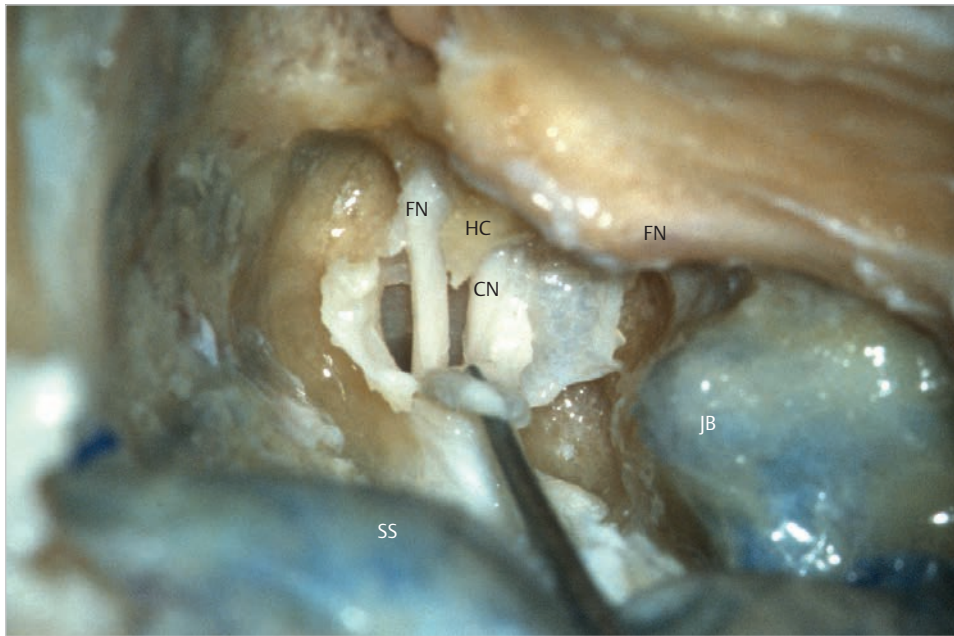


Fig. 14.13 The superior and inferior vestibular nerves are removed to visualize the facial nerve located anterosuperiorly and the cochlear nerve anteroinferiorly at the fundus of the internal auditory canal. CN, cochlear nerve; FN, facial nerve; HC, horizontal crest; JB, jugular bulb; SS, sigmoid sinus.

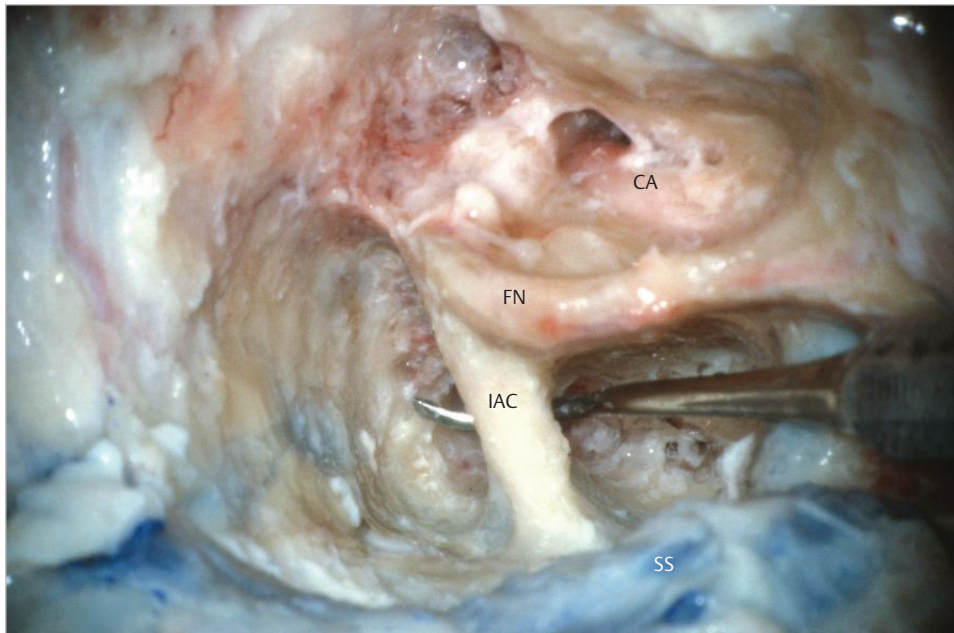


Fig. 14.14 The translabyrinthine approach can be extended anteriorly to reach the petrous apex by removing the bone anteriorly to the internal auditory canal. In this bone, the external auditory canal, the tympanic membrane, and the ossicles have been removed. CA, carotid artery; FN, facial nerve; IAC, internal auditory canal; SS, sigmoid sinus.

14.6.2 Surgical Anatomy of the Transotic Approach

In the translabyrinthine approach, presence of the cochlea impedes access to the petrous apex. Removal of the cochlea improves access to the petrous apex, and there is a good chance to preserve facial nerve function completely when proper technique is exerted. The approach is suitable for petrous apex

cholesteatomas with limited extension with good facial nerve function. However, presence of the nerve and the internal auditory canal in place significantly limits approach, and invisible area such as the medial face of the nerve, the anterior face of the internal auditory canal, and the medial face of the carotid artery may become source of residual disease even under endoscope assistance. Refer to ► Fig. 14.15, ► Fig. 14.16, ► Fig. 14.17, ► Fig. 14.18, ► Fig. 14.19.

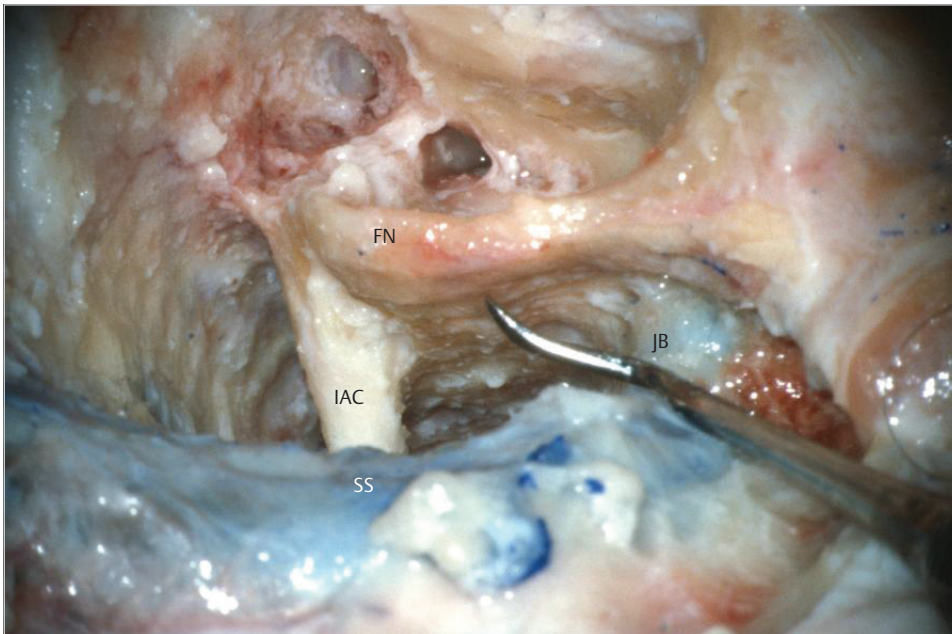


Fig. 14.15 The translabyrinthine approach is completed. Access to the petrous apex area is significantly impeded by the cochlea pointed by the instrument. FN, facial nerve; IAC, internal auditory canal; JB, jugular bulb; SS, sigmoid sinus.

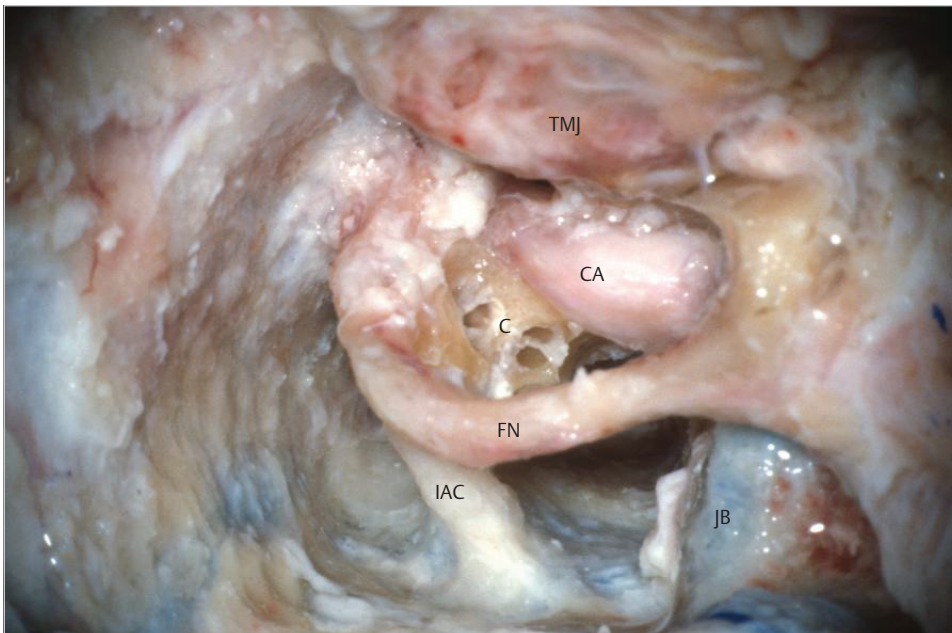


Fig. 14.16 The temporomandibular joint is exposed to maximize the approach anteriorly, and the carotid artery is skeletonized. Drilling of the cochlea is started. C, cochlea; CA, carotid artery; FN, facial nerve; IAC, internal auditory canal; JB, jugular bulb; TMJ, temporomandibular joint.

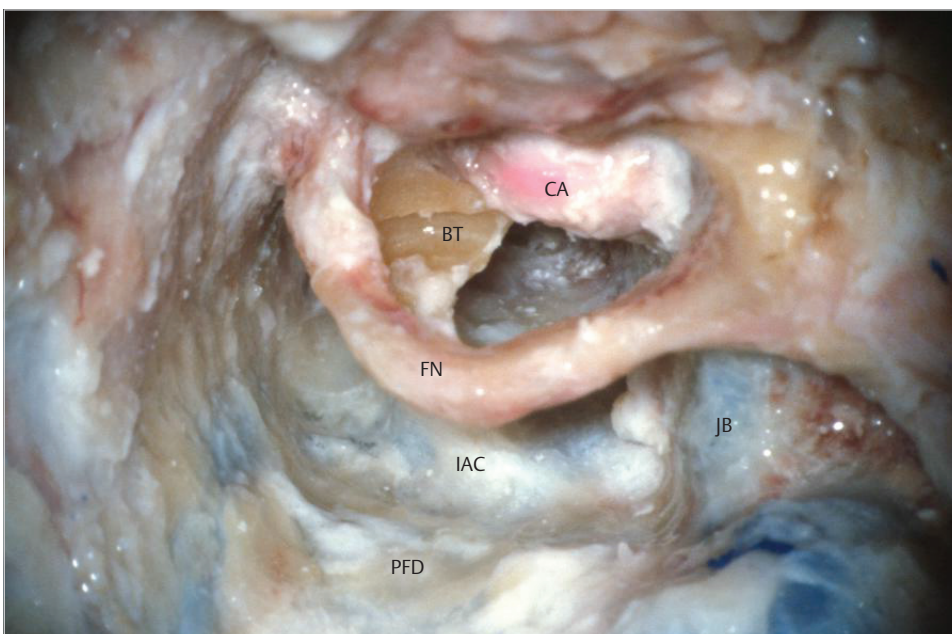


Fig. 14.17 The final part of the cochlea, the basilar turn of it, touching to the carotid artery is seen. BT, basal turn of cochlea; CA, carotid artery; FN, facial nerve; IAC, internal auditory canal; JB, jugular bulb; PFD, posterior fossa dura.

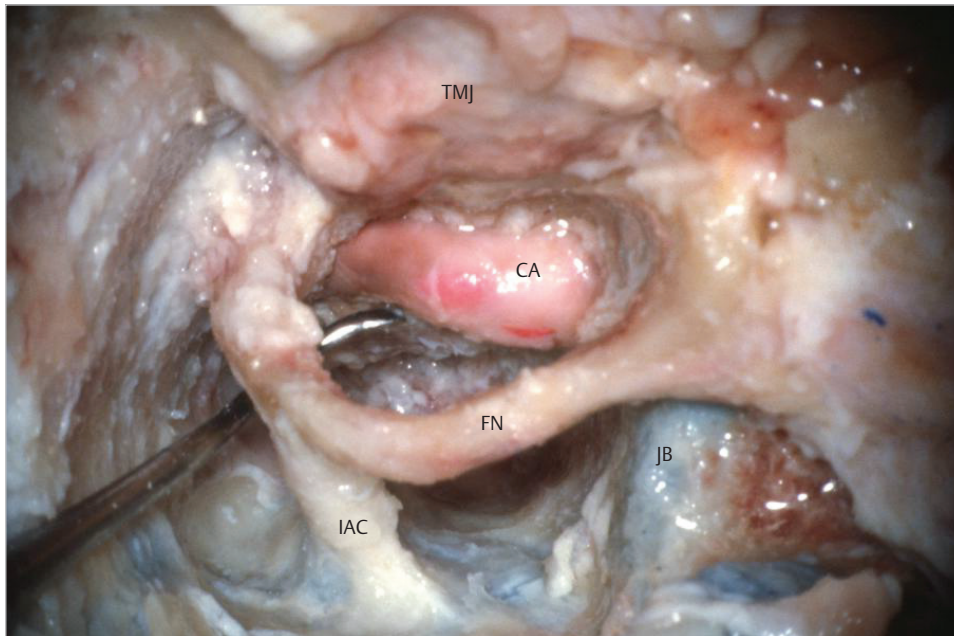


Fig. 14.18 The bone surrounding the internal auditory canal is totally removed. Note the enlarged access to the petrous apex even though the facial nerve courses in the center. CA, carotid artery; FN, facial nerve; IAC, internal auditory canal; JB, jugular bulb; TMJ, temporomandibular joint.

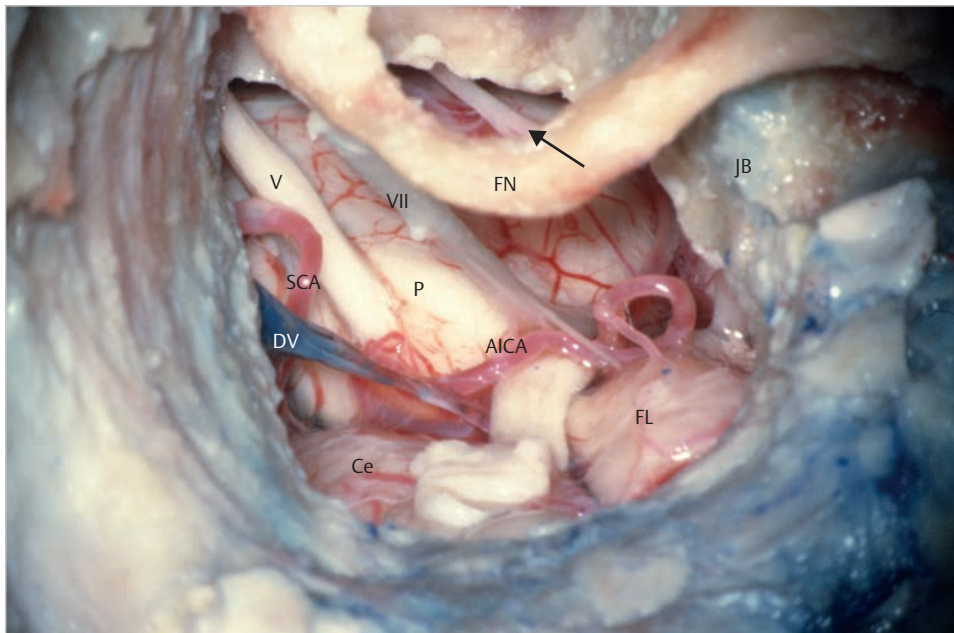


Fig. 14.19 The posterior fossa dura is opened to expose structures in the cerebellopontine angle. The facial nerve is located in the center. The trigeminal nerve is identified superiorly. The abducens nerve (arrow) runs obliquely in the preoptine cistern to reach Dollero's canal to path through the cavernous sinus. AICA, anteroinferior cerebellar artery; Ce, cerebellum; DV, Dandy's vein; FL, flocculus; FN, facial nerve; JB, jugular bulb; P, pons; SCA, superior cerebellar artery; V, trigeminal nerve; VII, facial nerve, intracanalicular.

14.6.3 Surgical Anatomy of the Modified Transcochlear Approach

In the modified transcochlear approach, the great superficial petrosal nerve that connects the geniculate ganglion of the facial nerve to the middle fossa dura is cut to reroute the facial nerve posteriorly. A big approach to the petrous apex without any impediment can be established with this procedure. A major drawback of this approach is complete facial nerve palsy due to

impaired blood supply along the great superficial petrosal nerve. Therefore, application of this approach to patients with residual facial nerve function should be fully discussed. On the other hand, this is a very good approach to the petrous apex when the facial nerve is severely damaged. The approach may not be sufficient to control the area anteriorly to the horizontal segment of the carotid artery. Refer to ►Fig. 14.20, ►Fig. 14.21, ►Fig. 14.22, ►Fig. 14.23, ►Fig. 14.24, ►Fig. 14.25, ►Fig. 14.26, ►Fig. 14.27, ►Fig. 14.28, ►Fig. 14.29, ►Fig. 14.30.



Fig. 14.20 A labyrinthectomy is completed, and the facial nerve is exposed to prepare for rerouting. CA, carotid artery; ET, eustachian tube; FN, facial nerve; IAC, internal auditory canal; JB, jugular bulb; P, promontory.

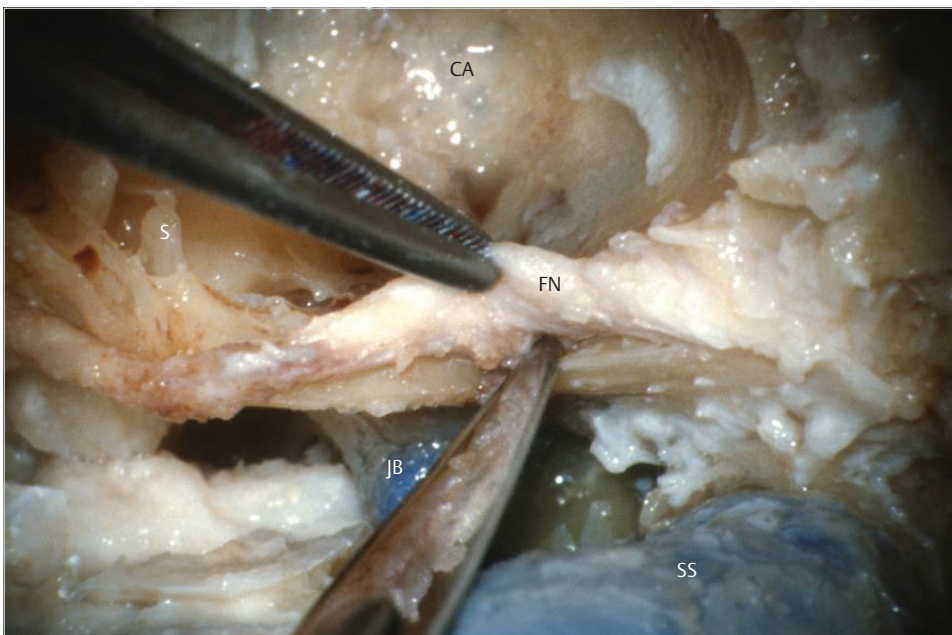


Fig. 14.21 The mastoid segment of the facial nerve requires sharp dissection to free from the medial wall of the fallopian canal. CA, carotid artery; FN, facial nerve; JB, jugular bulb; S, stapes; SS, sigmoid sinus.

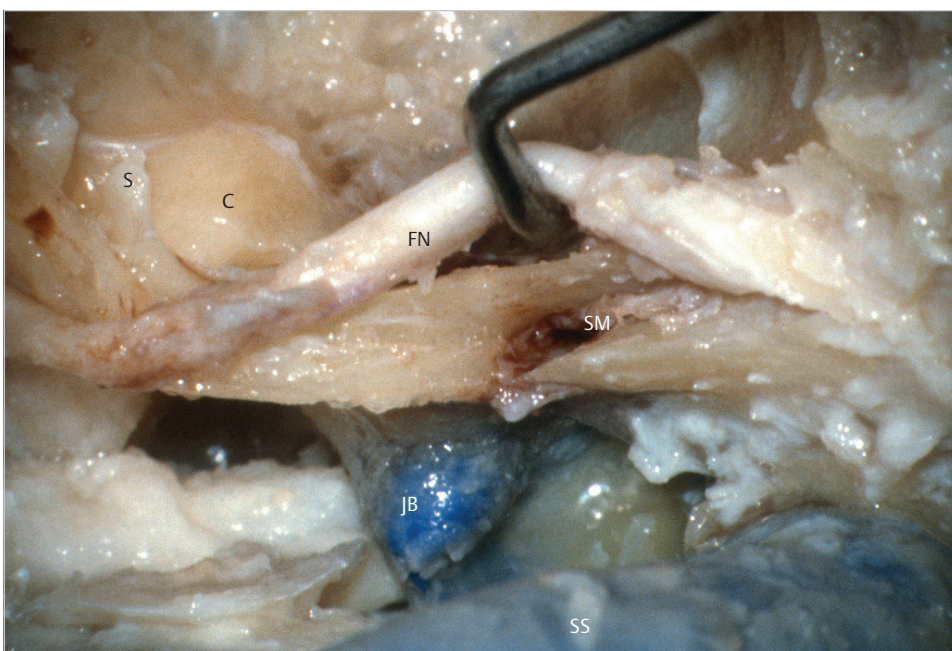


Fig. 14.22 The mastoid segment is pushed anteriorly to show the strong attachment to the stapedial muscle. C, cochlea; FN, facial nerve (mastoid segment); JB, jugular bulb; S, stapes; SM, stapedial muscle; SS, sigmoid sinus.

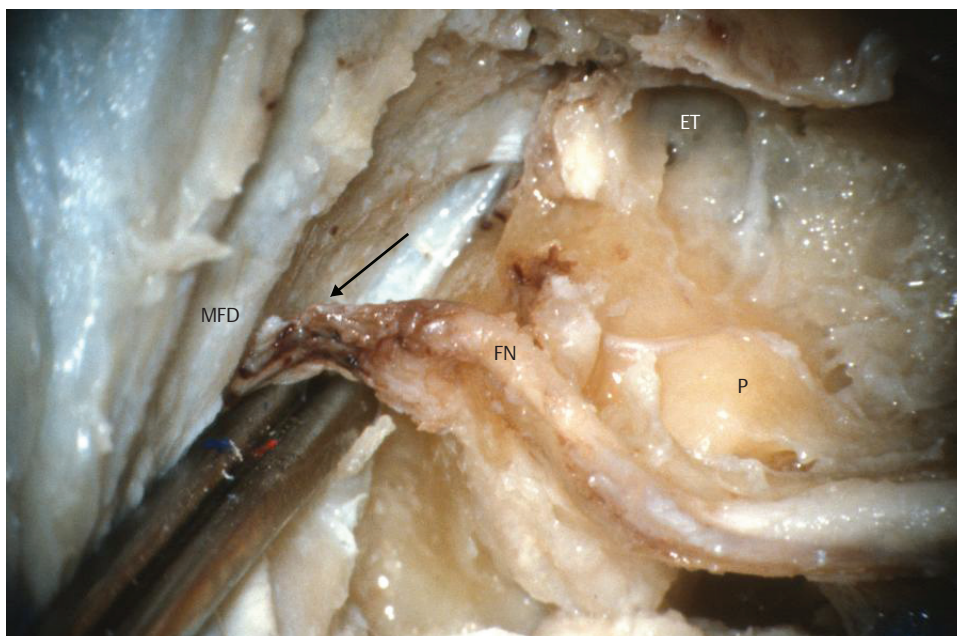


Fig. 14.23 The great superficial petrosal nerve (*arrow*) connecting the geniculate ganglion with the middle fossa dura is severed. In patients, the great superficial petrosal nerve should be bipolar coagulated before cutting to avoid bleeding. ET, eustachian tube; FN, facial nerve; MFD, middle fossa dura; P, promontory.

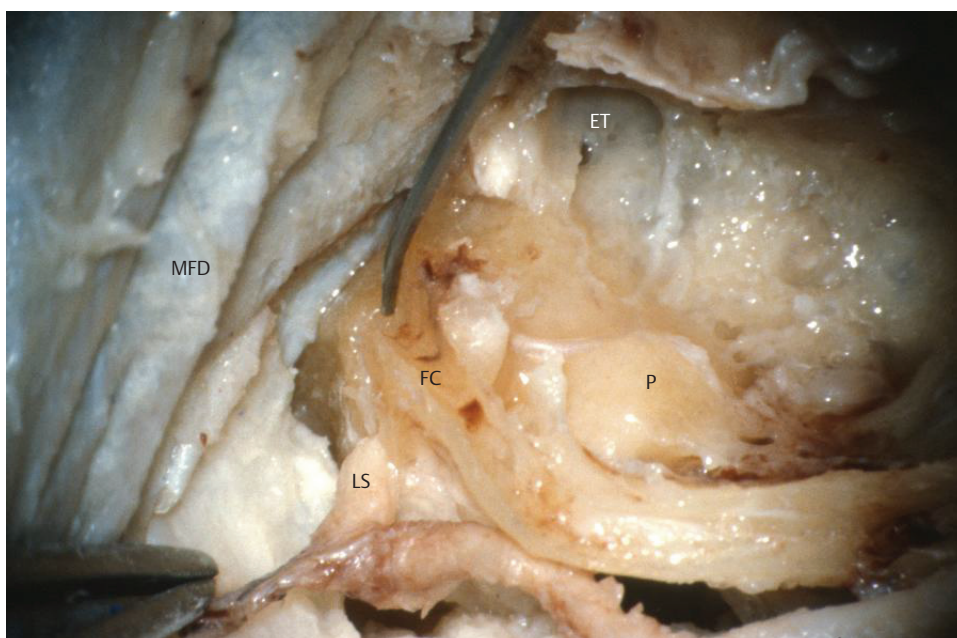


Fig. 14.24 Taking care not to stretch the facial nerve excessively, the tympanic and the labyrinthine segment of the nerve is detached from the fallopian canal. ET, eustachian tube; FC, fallopian canal; LS, labyrinthine segment (facial nerve); MFD, middle fossa dura; P, promontory.

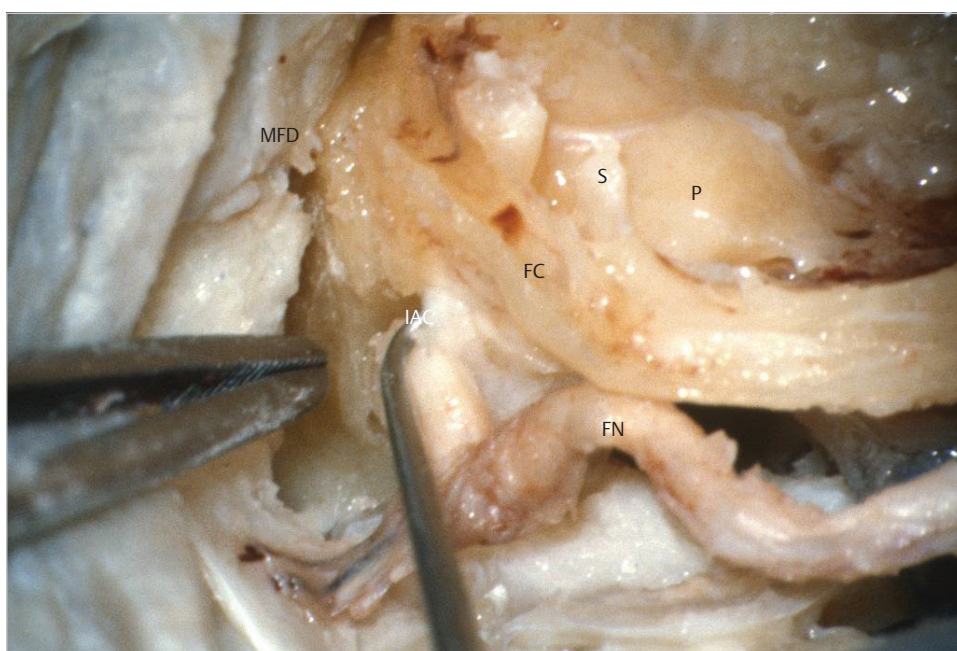


Fig. 14.25 The intracanalicular segment of the facial nerve inside the internal auditory canal is reflected posteriorly. FC, fallopian canal; FN, facial nerve; IAC, internal auditory canal; MFD, middle fossa dura; P, promontory; S, stapes.

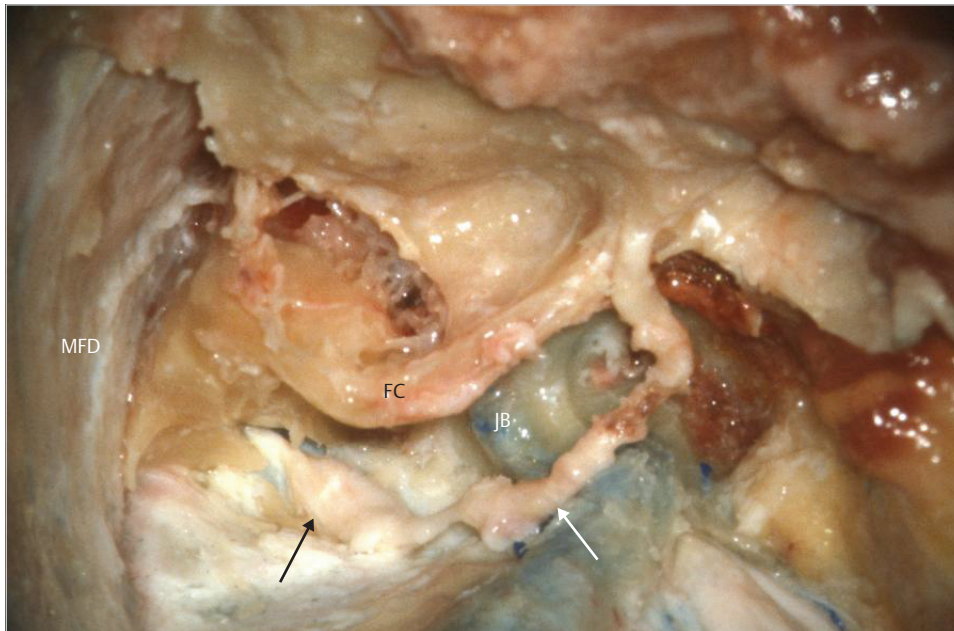


Fig. 14.26 Transposition of the facial nerve (arrows) is accomplished. FC, fallopian canal; JB, jugular bulb; MFD, middle fossa dura.

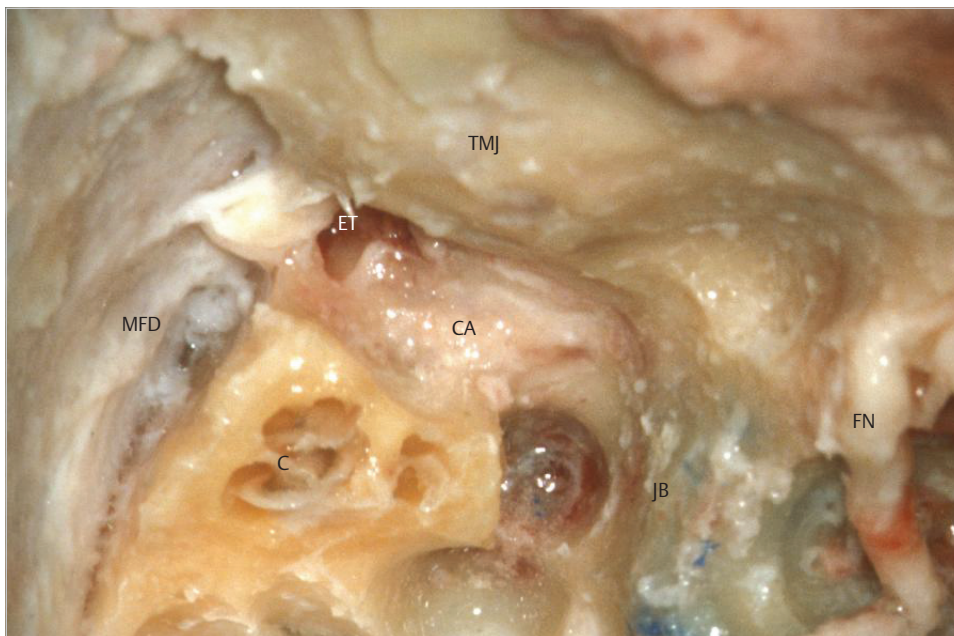


Fig. 14.27 The cochlea is started to be drilled. C, cochlea; CA, carotid artery; ET, eustachian tube; FN, facial nerve; JB, jugular bulb; MFD, middle fossa dura; TMJ, temporomandibular joint.

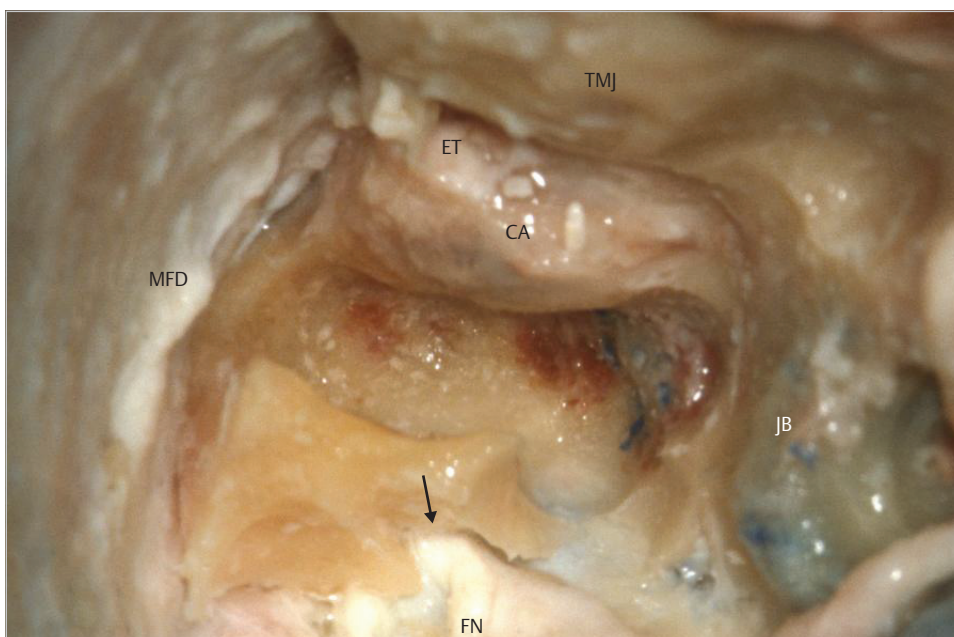


Fig. 14.28 The fallopian canal and the cochlea are removed. The porus of the internal auditory canal is seen. CA, carotid artery; ET, eustachian tube; FN, facial nerve; JB, jugular bulb; MFD, middle fossa dura; TMJ, temporomandibular joint.

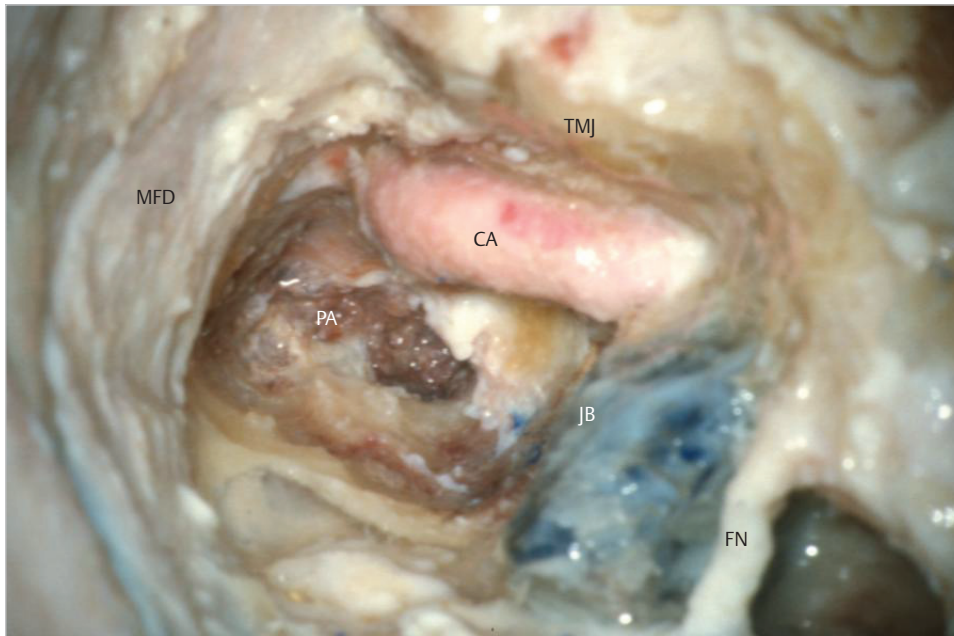


Fig. 14.29 Note the wide approach to the petrous apex. Bone marrow in the petrous apex is seen. The vertical segment and the posterior face of the horizontal segment of the carotid artery are under control. However, the approach does not permit complete control of the area anteriorly to the carotid artery due to the presence of the temporomandibular joint. CA, carotid artery; FN, facial nerve; JB, jugular bulb; MFD, middle fossa dura; PA, petrous apex; TMJ, temporomandibular joint.

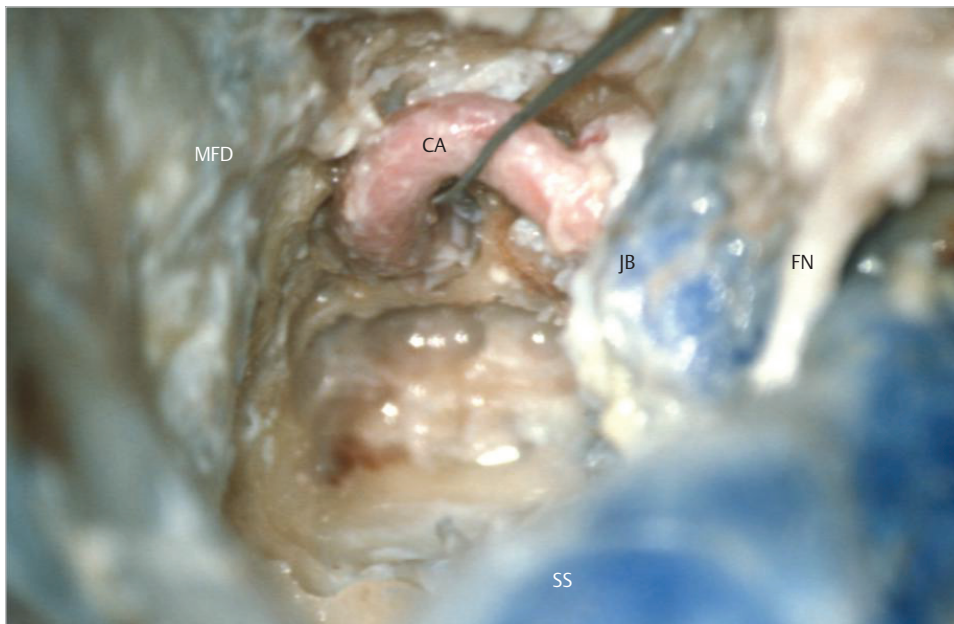


Fig. 14.30 The bone anteriorly to the vertical portion of the carotid artery is removed for partial mobilization of the artery to give better control. CA, carotid artery; FN, facial nerve; JB, jugular bulb; MFD, middle fossa dura; SS, sigmoid sinus.

14.6.4 Surgical Anatomy of the Infratemporal Fossa Approach Type B

In some extensive case of petrous bone cholesteatoma, control of the horizontal intrapetrous portion of the carotid artery is required. To control that portion safely, anterior extension of the approach is required. The infratemporal fossa approach is designed to manage pathology in the petrous apex and mid-clivus by dislocating the temporomandibular joint inferiorly.

The procedure permits removal of the medial wall of the glenoid fossa, transection of the structures lying laterally to the horizontal portion of the carotid artery such as the middle meningeal artery, the third branch of the trigeminal nerve (mandibular nerve), and the eustachian tube from lateral. In petrous bone cholesteatoma surgery, the approach is often combined with removal of the labyrinth and reconstruction of the facial nerve. Refer to ► Fig. 14.31, ► Fig. 14.32, ► Fig. 14.33, ► Fig. 14.34, ► Fig. 14.35, ► Fig. 14.36.

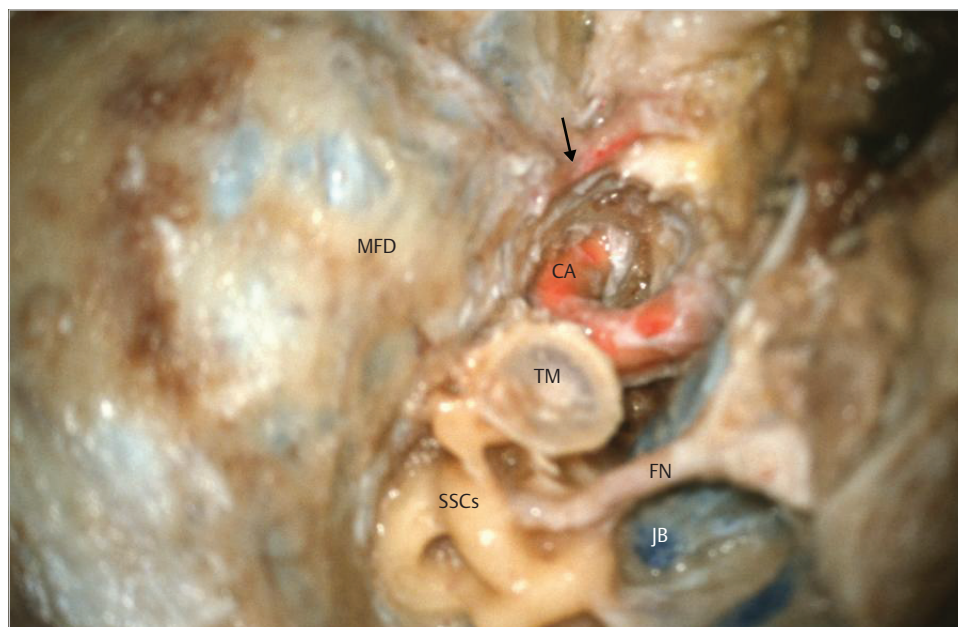


Fig. 14.31 The glenoid fossa is removed and the osseous portion of the eustachian tube is drilled to expose the anterior face of the intrapetrous horizontal portion of the carotid artery. The middle meningeal artery (*arrow*) branches from the maxillary artery passing through the foramen spinosum is seen. CA, carotid artery; FN, facial nerve; JB, jugular bulb; MFD, middle fossa dura; SSCs, semicircular canals; TM, tympanic membrane.

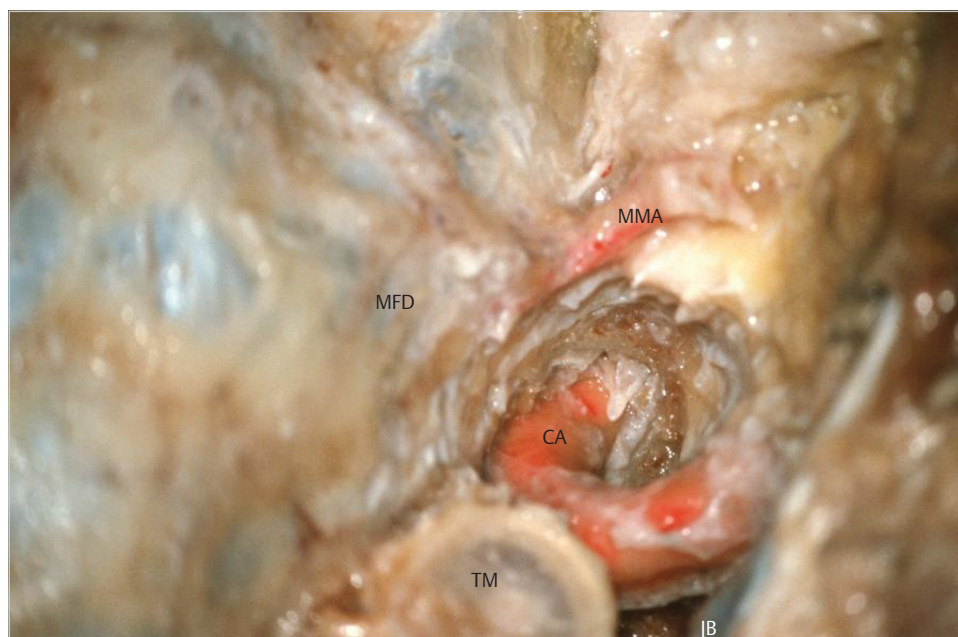


Fig. 14.32 Closer view. The posterior part of the horizontal portion of the carotid artery can be controlled at this moment. The middle meningeal artery and the mandibular nerve impede access to more anterior part. CA, carotid artery (horizontal portion); JB, jugular bulb; MFD, middle fossa dura; MMA, middle meningeal artery; TM, tympanic membrane.

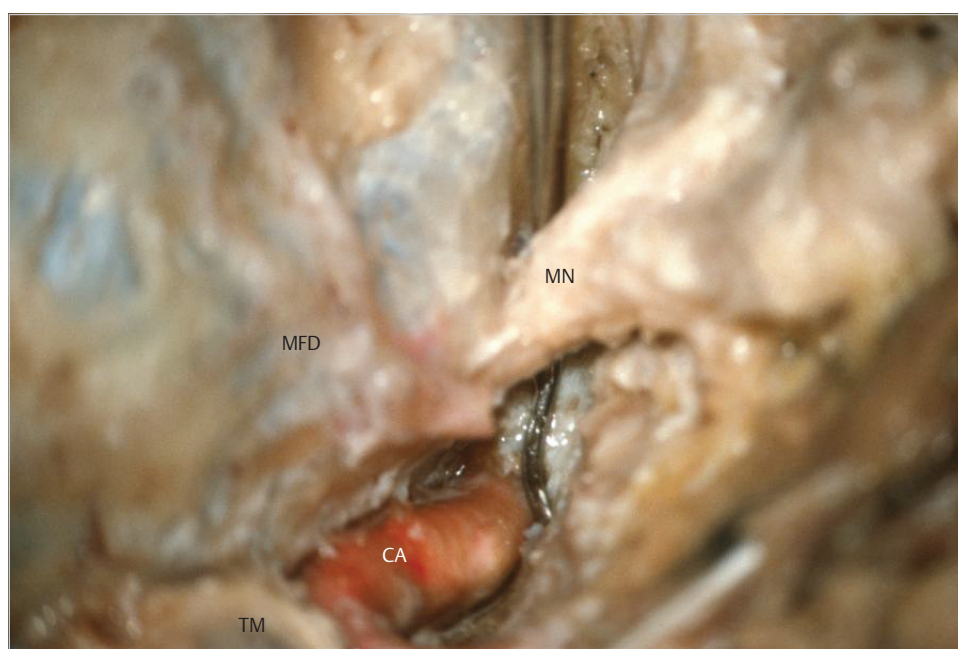


Fig. 14.33 The middle meningeal artery is cut, and drilling is advanced medially to expose the mandibular nerve passing through the foramen ovale. CA, carotid artery; MFD, middle fossa dura; MN, mandibular nerve; TM, tympanic membrane.

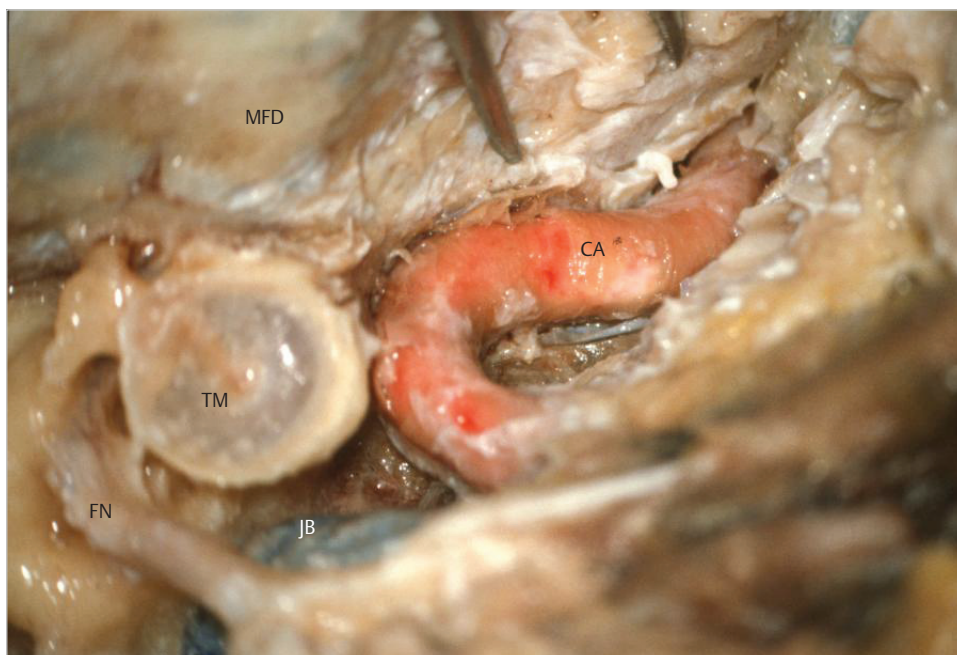


Fig. 14.34 After sacrificing the mandibular nerve, the osseous eustachian tube is further drilled to expose more medial part of the carotid artery. CA, carotid artery; FN, facial nerve; JB, jugular bulb; MFD, middle fossa dura; TM, tympanic membrane.

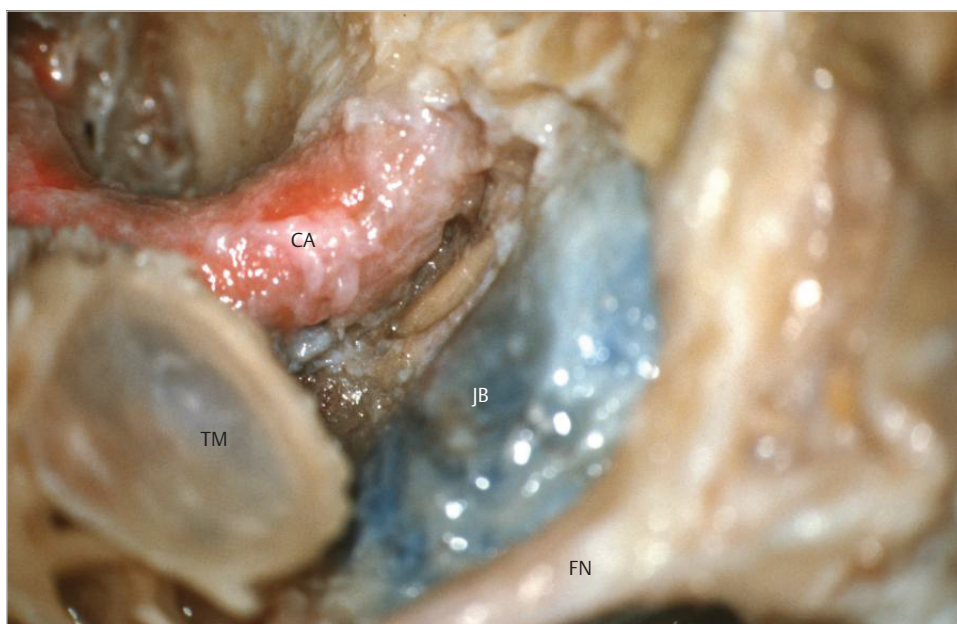


Fig. 14.35 The glossopharyngeal nerve running just anteriorly to the jugular bulb, posteriorly to the carotid artery is shown. CA, carotid artery; FN, facial nerve; JB, jugular bulb; TM, tympanic membrane.

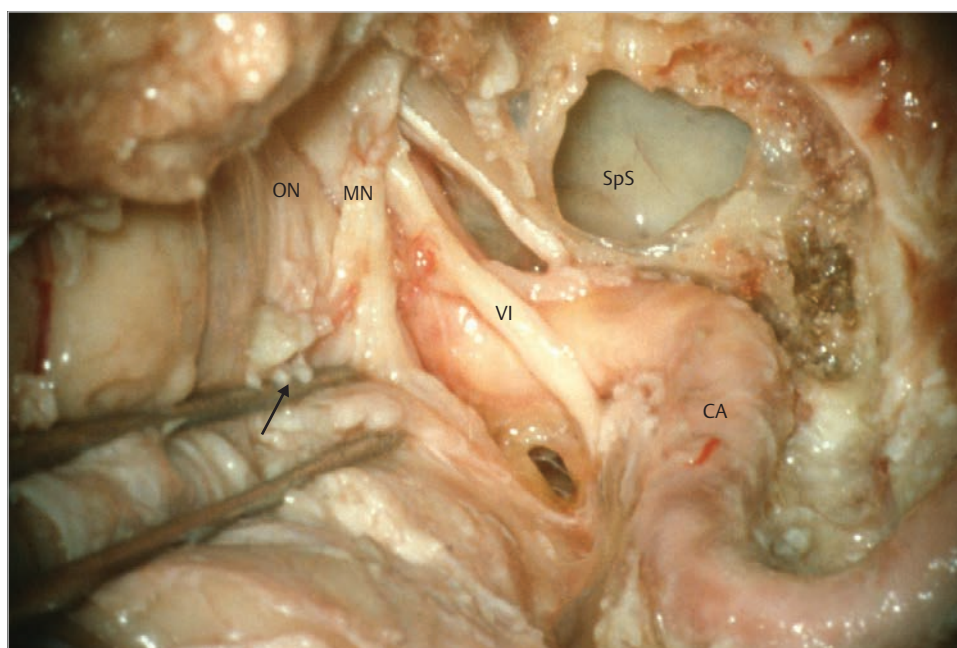


Fig. 14.36 More anterior extension of the approach by drilling the pterygoid process allows access to the area of the sphenoid sinus and the nasopharynx, making the approach infratemporal fossa type C. The dura encapsulating the trigeminal ganglion forming Meckel's cave is opened superiorly (arrow). The cavernous sinus is opened to expose the cavernous segment of the carotid artery and the abducent nerve passing just laterally to it. CA, carotid artery; MN, mandibular nerve; ON, ophthalmic nerve; SpS, sphenoid sinus; VI, abducent nerve.

14.7 Operating Room Setup for PBC Surgery

Surgery of petrous bone cholesteatoma is in a category of lateral skull base surgery, and special preparation of operating field as skull base surgery and general anesthesia is required. Arrangement of the operating theater basically stays the same as the middle ear surgery, and the anesthesia machine is placed at the leg of the table and keeps the same location in all the various approaches (see Fig. 2.3) except the middle fossa approach in which the surgeon should sit superiorly to the head of the patient (► Fig. 14.37).

The patient is secured to the table at the wrists and the thigh (► Fig. 14.38).

14.7.1 Monitoring

A Nerve Integrity Monitor-2 (NIM-2) (Xomed Treace, Jacksonville, FL) is used for facial nerve monitoring. Pairs of electrodes are placed in the orbicularis oculi and orbicularis oris muscles to allow continuous electromyographic monitoring of the facial nerve. In cases where hearing preservation is aimed at, an ipsilateral ear stimulator is applied, and electrodes are placed for auditory brain-stem responses and direct eighth nerve stimulation (► Fig. 14.39).



Fig. 14.38 The patient is secured to the table at the wrist and thigh. The anesthesia machine is placed at the leg of the table and keeps the same location in all the various approaches.

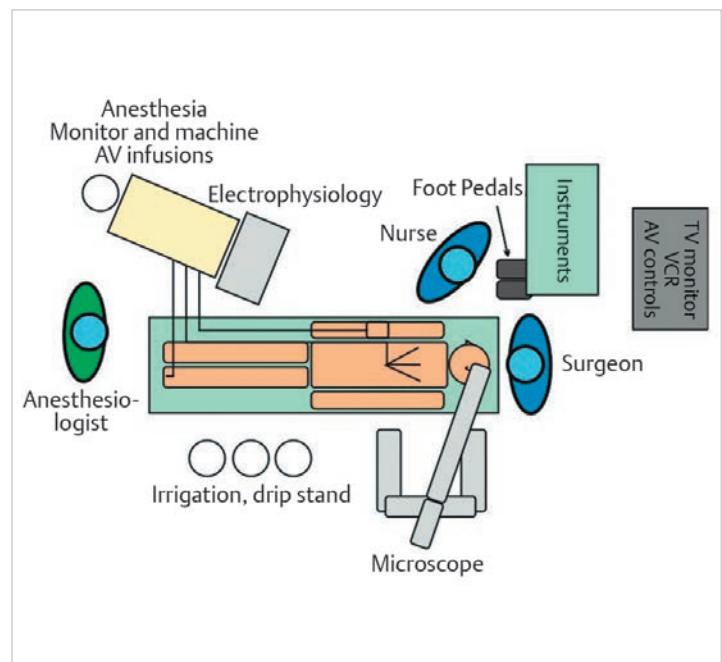


Fig. 14.37 The arrangement of the operating room in middle fossa approach.



Fig. 14.39 The patient is prepared for surgery in a hearing preservation procedure. The electrodes for facial nerve monitoring can be seen. Notice the additional electrodes and the microphone placed in the ear for eighth nerve monitoring.

14.7.2 Preparation of the Operative Site

The operative site is shaved. The area is then prepared with ether 10 ppm followed by Citrosil (Glaxo, Italy). The abdomen is also prepared in the same manner. The patient is then draped in layers (► Fig. 14.40) using sterile adhesive drapes incorporating a clear window for the operative site and a fluid collecting system.

14.7.3 Instruments

Most of the instruments used in the middle ear cholesteatoma surgery are used in the petrous bone cholesteatoma surgery. However, to manipulate intracranial structures and delicate vital

structures that is not appeared in middle ear surgery, some special instruments need to be prepared.

Suction Irrigation

Traditional suction tips can be very dangerous when used near delicate neurovascular structures. The Brackmann suction irrigation tips equipped with side holes near the blunt tip (► Fig. 2.16) are used for intradural work or during manipulations of fine structures such as exposed facial nerve.

Bipolar Coagulation

The bipolar coagulation is an essential tool in skull base surgery. Different tip sizes should be available. Fine tips (0.3 mm) are used in the most delicate works for coagulating fine intracranial vessels. Larger tips (1 and 1.3 mm) are used for coagulation of the large vessels near the dura (► Fig. 14.41a, b).

In our practice, we prefer the use of the Vesalius machine (molecular resonance generator) (► Fig. 2.17). This machine limits a rise in temperature to preserve function of vital structures nearby, and avoid the burned tissue sticking to the tip of the bipolar that may cause damaging underlying structures.

Microinstruments

The minimal number of instruments should be used. An overcrowded instruments' table with numerous useless items is the most disturbing nightmare for the scrub nurse in these lengthy procedures. The instruments' table should be organized in the same order to facilitate handling and proper and prompt management by the scrub nurse (► Fig. 14.42, ► Fig. 14.43, ► Fig. 14.44, ► Fig. 14.45, ► Fig. 14.46, ► Fig. 14.47, ► Fig. 14.48).

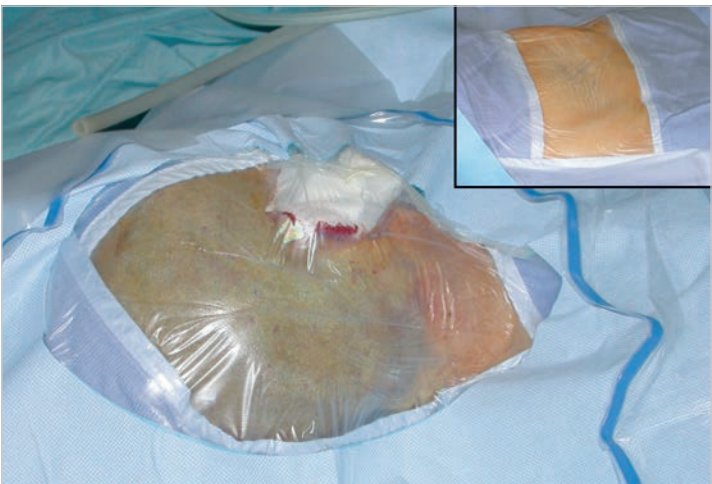


Fig. 14.40 Patient is draped with adhesive drapes. Inset (upper right) shows preparation of the abdomen for obtaining the fat used for closure at the end of the procedure.

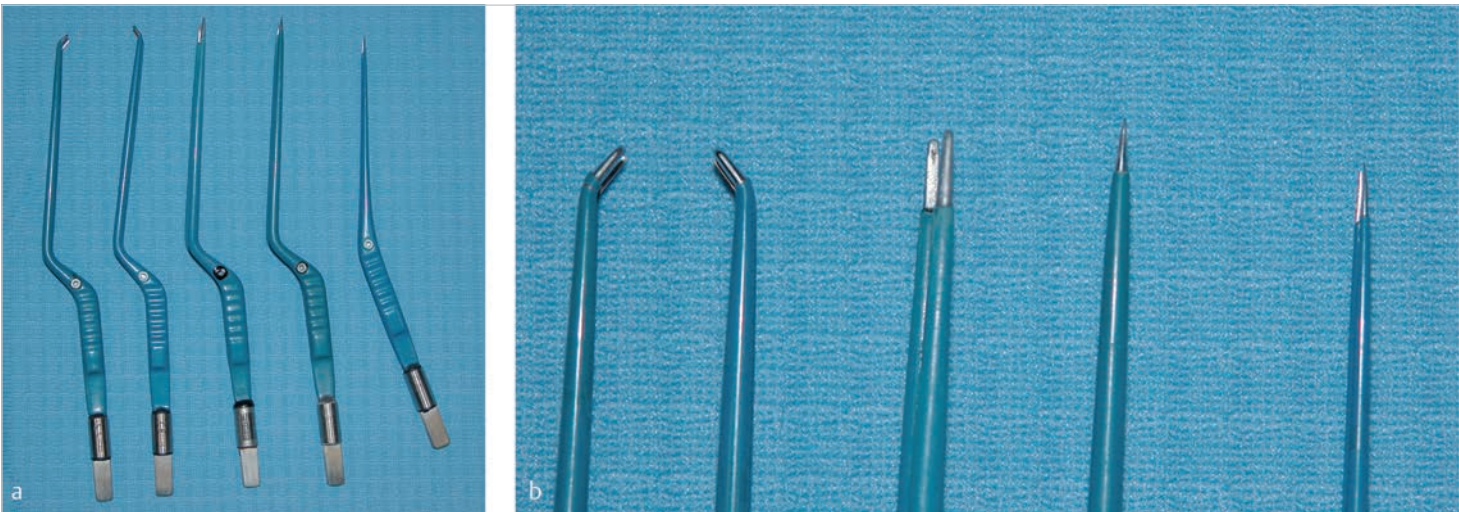


Fig. 14.41 (a) Different bipolar forceps. These include angled forceps, bayonet forceps with straight tips, and bayonet forceps with angled tips. (b) A higher magnification showing the different tips sizes of the bipolar forceps.

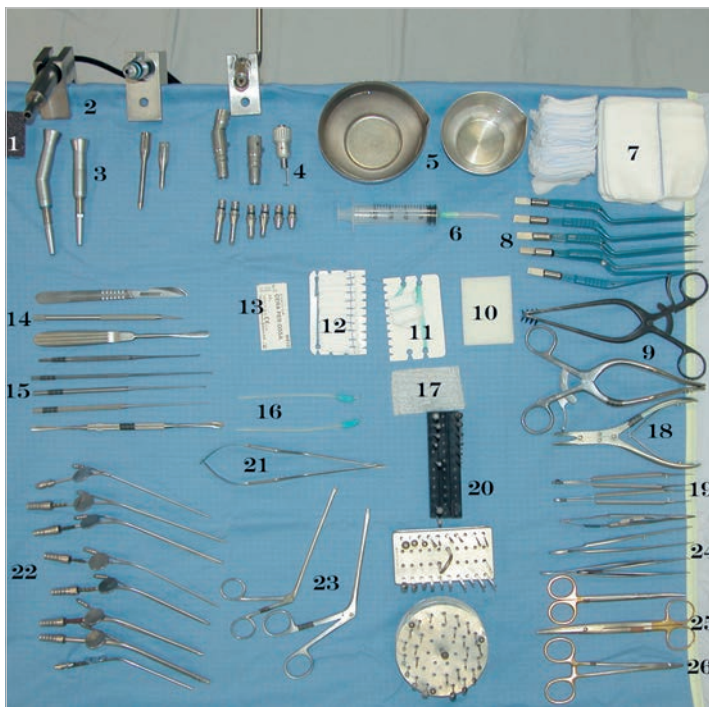


Fig. 14.42 Operating table setup for skull base surgery.

1. Scratch pad.
2. Micro motors.
3. Hand pieces.
4. Midas Rex craniotome handpiece.
5. Metal cups for saline and for placement of the abdominal fat.
6. 20-cc syringe.
7. Gauze.
8. Different bipolar forceps.
9. Self-retaining retractors.
10. Absorbable gelatine sponge (Spongstan, Ferrosan).
11. Surgical Patties (Merocel, Connecticut, CT).
12. American Surgical Sponges, strung (American Silk Sutures Inc., Lynn, MA).
13. Bone wax.
14. Surgical knives.

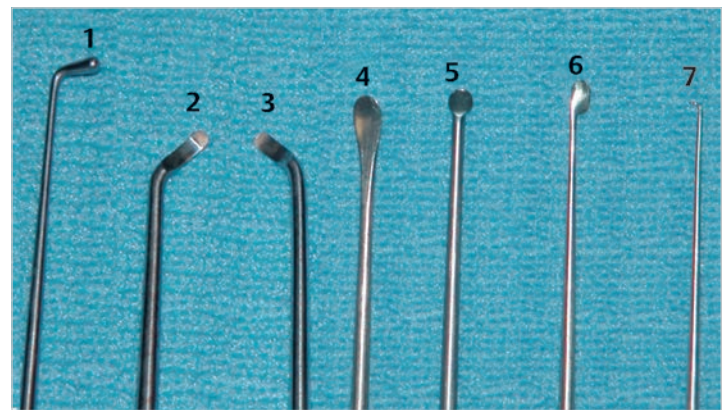


Fig. 14.43 Enlarged view of the microinstruments. (1) Blunt tip right-angled hook. (2) Double-curved raspatory (right sided). (3) Double-curved raspatory (left sided). (4) Straight microdissector. (5) Round dissector 45 degrees. (6) Vertical dissector. (7) Ninety-degree-angled sharp hook.

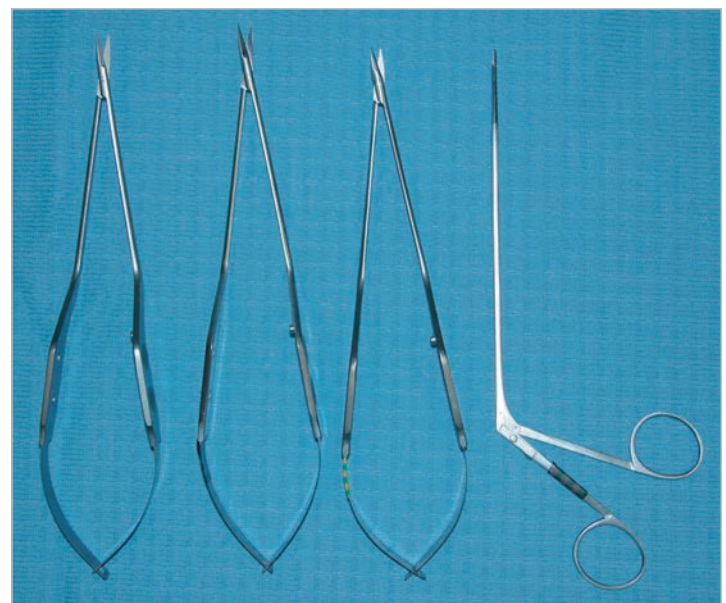


Fig. 14.44 Different types of microscissors.



Fig. 14.45 Different types of microforceps. Inset on right upper side shows an enlarged view of the tips demonstrating the different types and sizes.



Fig. 14.46 Microsurgical instruments for facial and other cranial nerves anastomosis. (1) and (2) Straight microtissue forceps of different lengths. (3) Microtissue forceps with an angled tip. (4) Microsurgery needle holder with latch. (5) Microscissors. (6) Microsuturing forceps.

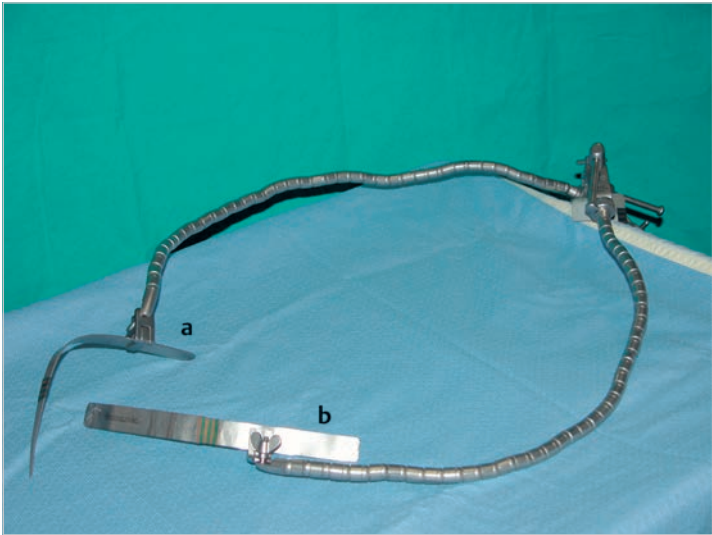


Fig. 14.47 Leyla retractor with Fukushima blade and malleable blade.

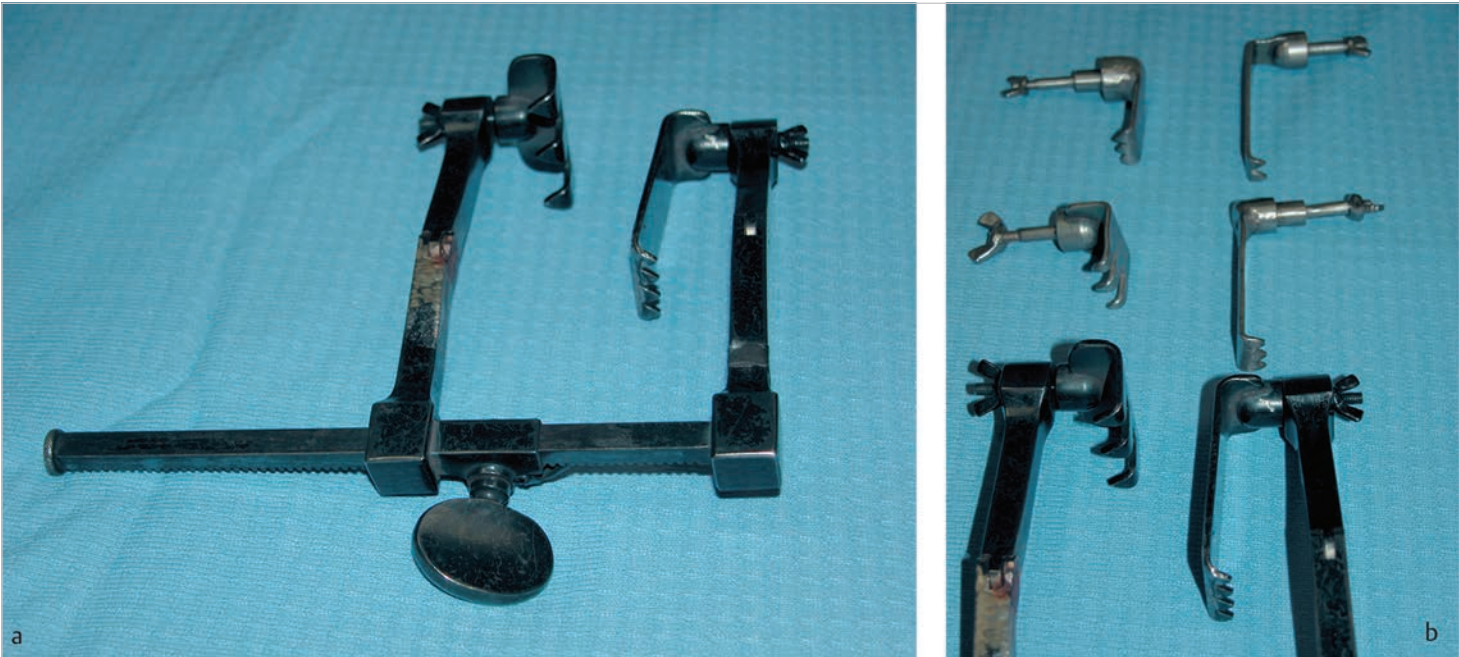


Fig. 14.48 (a) A higher magnification showing the different tip sizes of the bipolar forceps. (b) Different blades we use for use with the infratemporal fossa retractor to fit different situations.

Case 14.1 (Right Ear)

See ► Fig. 14.49, ► Fig. 14.50, ► Fig. 14.51, ► Fig. 14.52, ► Fig. 14.53, ► Fig. 14.54, ► Fig. 14.55, ► Fig. 14.56, ► Fig. 14.57, ► Fig. 14.58, ► Fig. 14.59, ► Fig. 14.60, ► Fig. 14.61, ► Fig. 14.62, ► Fig. 14.63.

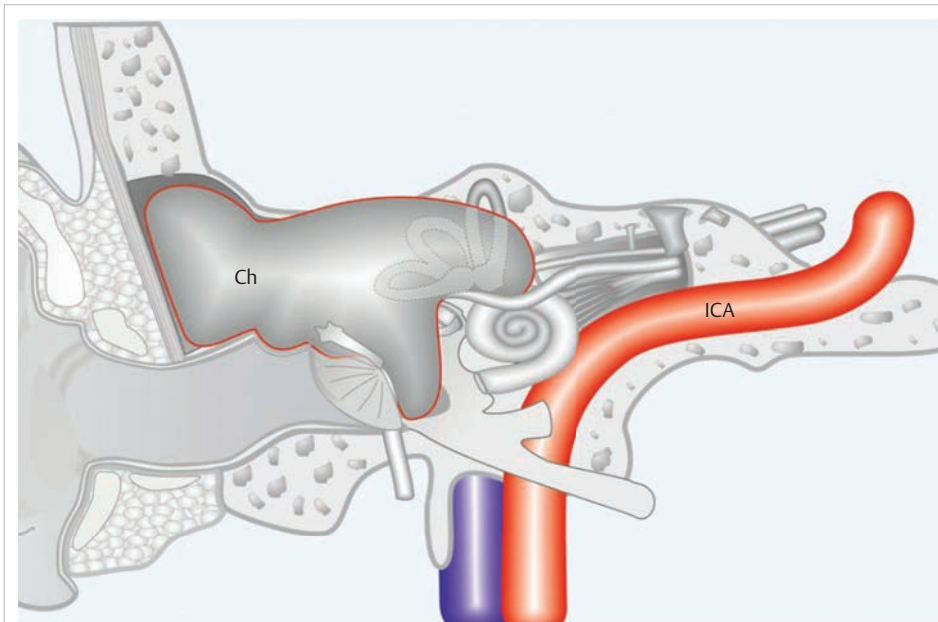


Fig. 14.49 A case of supralabyrinthine petrous bone cholesteatoma after canal wall up tympanoplasty removed with translabyrinthine approach. The cholesteatoma fills the mastoid and the attic to reach the posterior mesotympanum, and the posterior labyrinth is eroded. Ch, cholesteatoma; ICA, internal carotid artery.

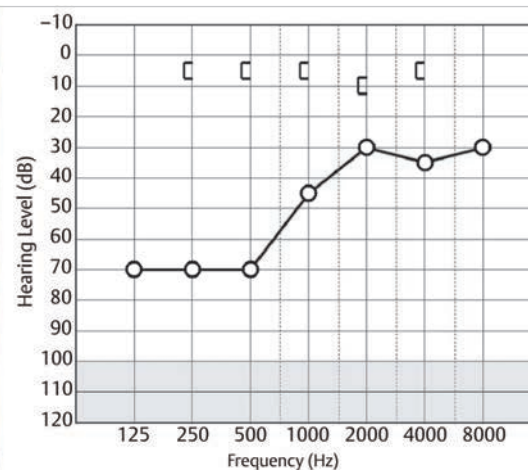


Fig. 14.50 A 24-year-old man undertook right tympanoplasty two times 12 years ago. Repetitive otorrhea worsened 1 year before, and hearing loss with dizziness and intermittent tinnitus developed. The otoscopy revealed whitish mass behind the posterosuperior quadrant of the intact tympanic membrane. Preoperative audiogram shows considerable air-bone gap in low frequencies, but bone conduction stays normal.

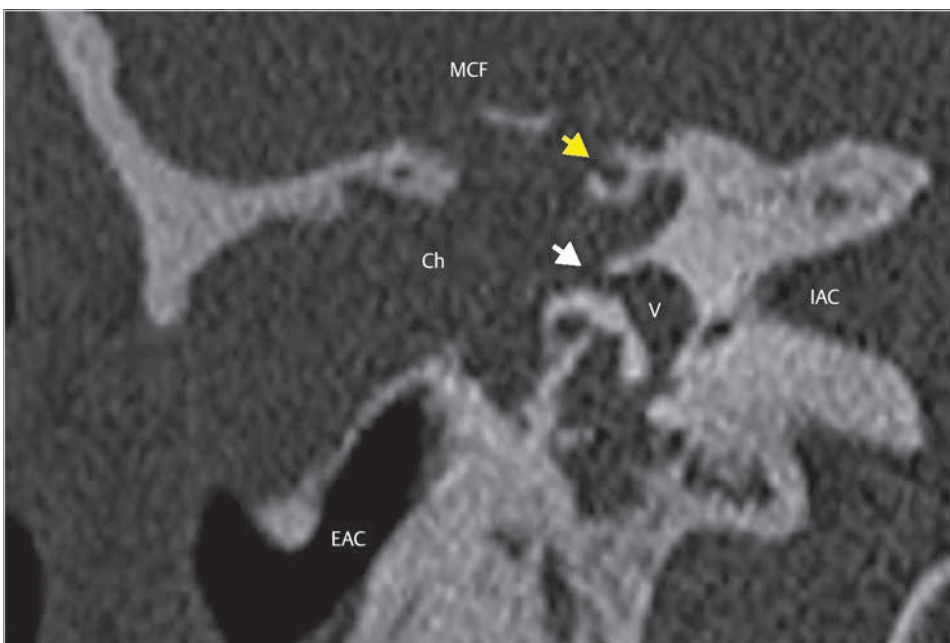


Fig. 14.51 The coronal CT scan demonstrates soft tissue density filling the mastoid cavity eroding heavily the medial wall of the antrum. Large fistulae in both the superior (yellow arrow) and the lateral semicircular canals (white arrow) are identified. Ch, cholesteatoma; EAC, external auditory canal; IAC, internal auditory canal; MCF, middle cranial fossa; V, vestibule.

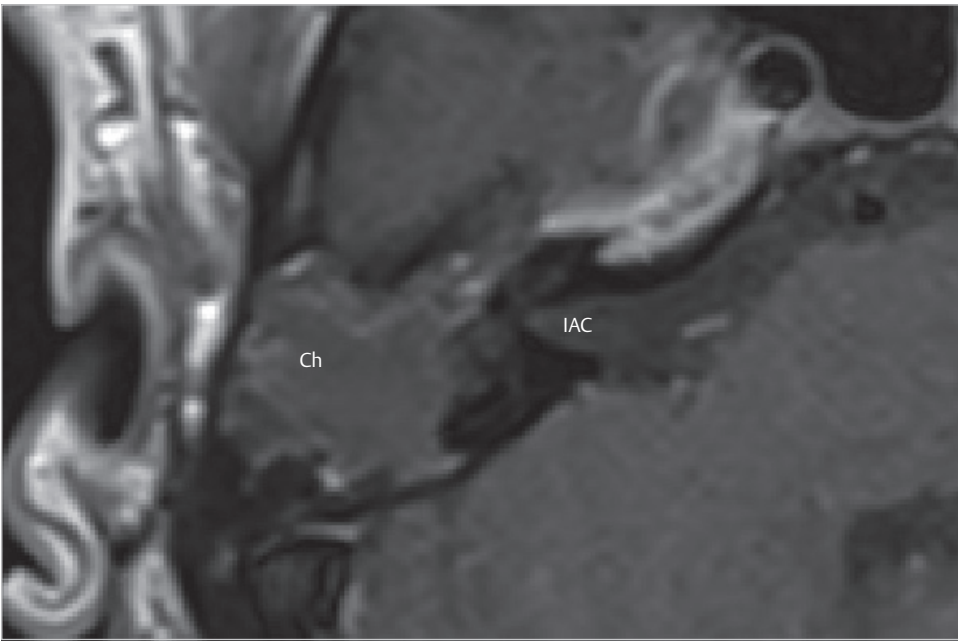


Fig. 14.52 The axial section of T1-weighted image of MRI showed mid signal intensity in the mastoid. Ch, cholesteatoma; IAC, internal auditory canal.

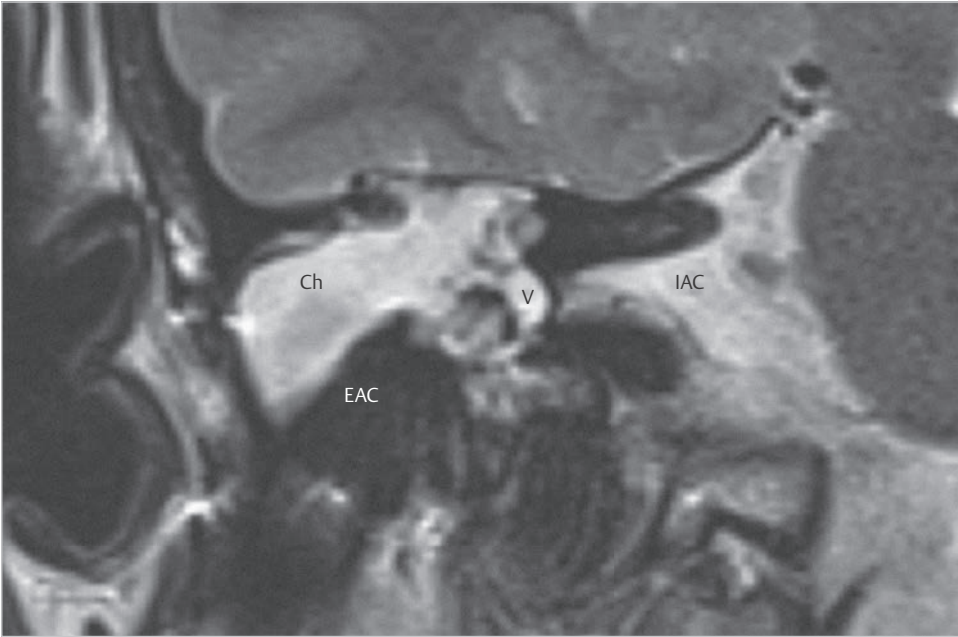


Fig. 14.53 The coronal section of T2-weighted image shows high signal intensity filling the mastoid. Presence of fistulae is better recognized in CT due to higher space resolution. Ch, cholesteatoma; EAC, external auditory canal; IAC, internal auditory canal; V, vestibule.

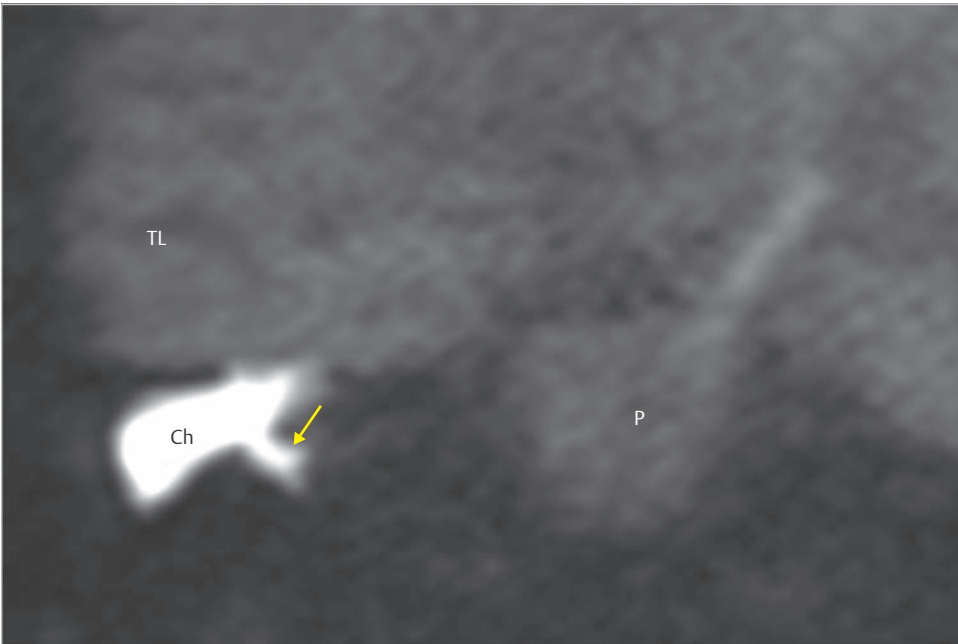


Fig. 14.54 A very high signal intensity in the coronal section of diffusion-weighted MRI corresponds to cholesteatoma. A small protrusion indicates descending of cholesteatoma to the posterior mesotympanum (arrow). Ch, cholesteatoma; P, pons; TL, temporal lobe.

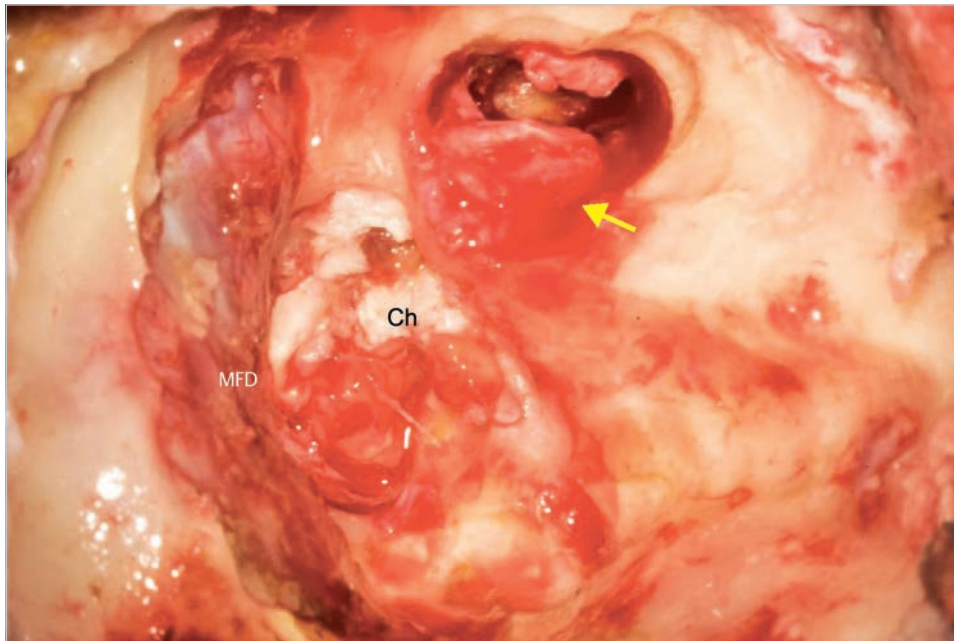


Fig. 14.55 Because of heavy erosion in the labyrinth, labyrinthectomy is indicated. After removal of the tympanomeatal flap and closure of the external auditory canal, a canal wall down mastoidectomy is carried out. The middle fossa dura is uncovered to facilitate access to the supralabyrinthine cholesteatoma. Debulking of cholesteatoma exposed the medial wall of the antrum. Cholesteatoma descending to the posterior mesotympanum is seen (*arrow*). Ch, cholesteatoma; MFD, middle fossa dura.

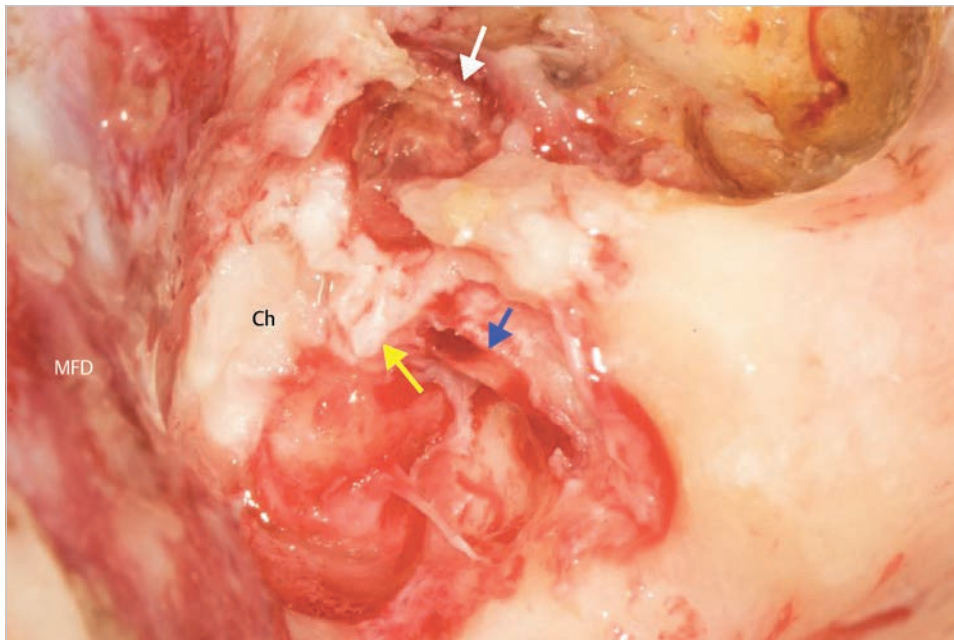


Fig. 14.56 Cholesteatoma is reduced to expose large opening of the lateral semicircular canal (*blue arrow*) and granulation tissue formed inside of cholesteatoma in the tympanic cavity (*white arrow*). The area of ampullae of the lateral and the superior semicircular canals are infiltrated by the cholesteatoma (*yellow arrow*). Ch, cholesteatoma; MFD, middle fossa dura.

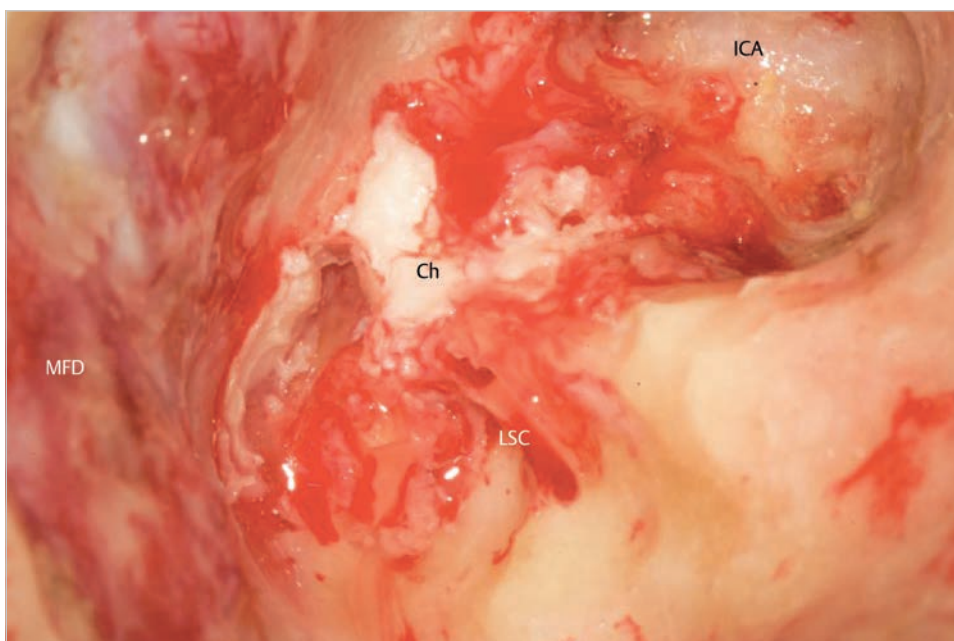


Fig. 14.57 Cholesteatoma eroding two ampullae, covering the tympanic segment of the facial nerve is seen. The carotid artery is identified in the anteroinferior wall of the tympanic cavity. Ch, cholesteatoma; ICA, internal carotid artery; LSC, lateral semicircular canal; MFD, middle fossa dura.

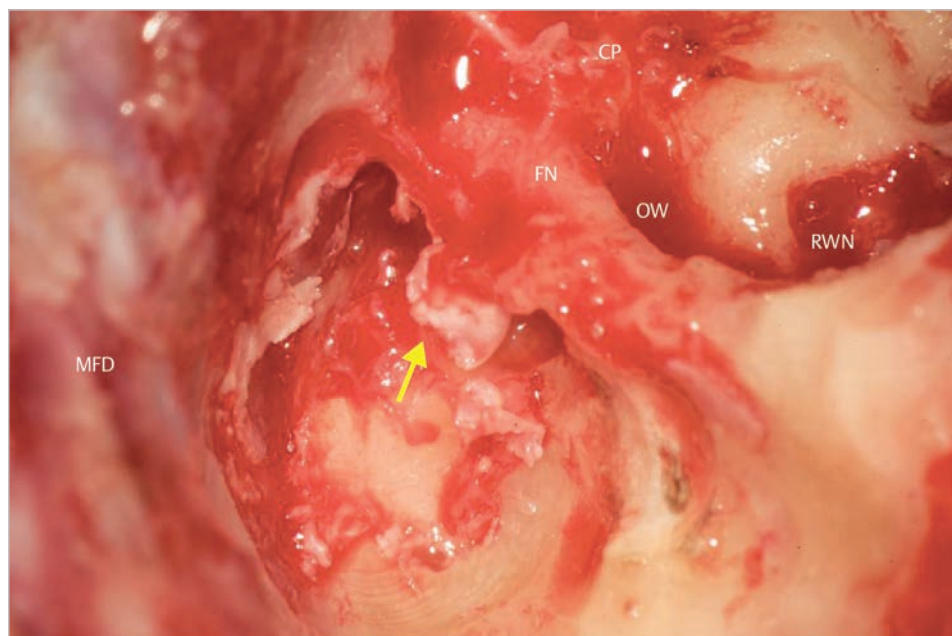


Fig. 14.58 The lateral semicircular canal is drilled and ampullae of the lateral and the superior semicircular canals are opened. The final piece of cholesteatoma infiltrating the vestibule is seen (arrow). Dissection of cholesteatoma from the tympanic cavity revealed the tympanic segment of the facial nerve and the oval window. The superstructure of the stapes is completely eroded. CP, cochleariform process; FN, facial nerve; MFD, middle fossa dura; OW, oval window; RWN, round window niche.

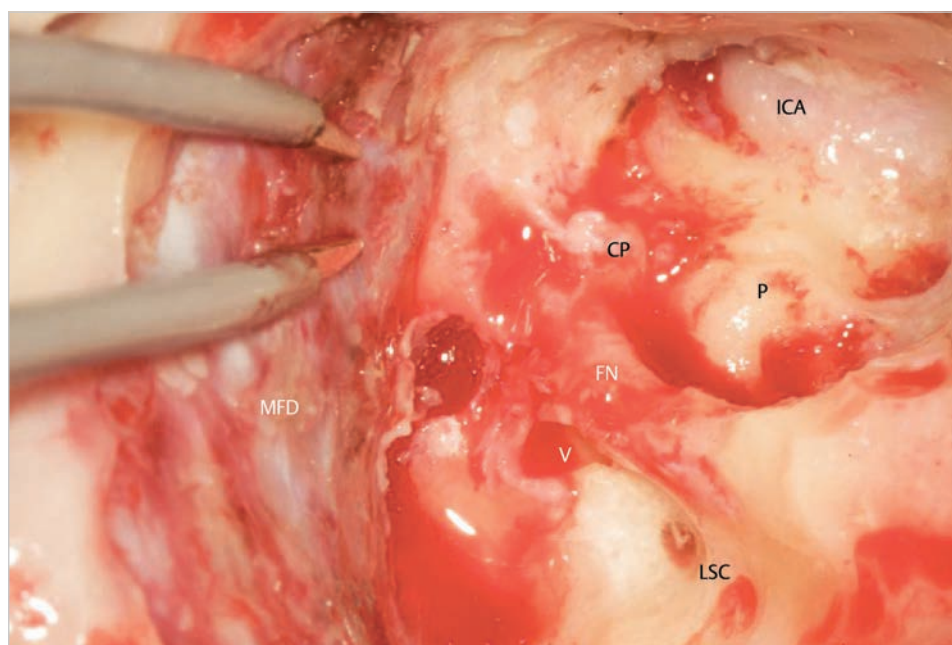


Fig. 14.59 Bipolar coagulation of the dura serves for both eradication of cholesteatoma matrix and shrinking of dura to make room for further dissection. CP, cochleariform process; FN, facial nerve; ICA, internal carotid artery; LSC, lateral semicircular canal; MFD, middle fossa dura; P, promontory; V, vestibule.



Fig. 14.60 Cholesteatoma infiltrating the area medial to the superior semicircular canal is dissected with a microdissector. A middle fossa retractor is used to enlarge access to this area. Ch, cholesteatoma; CP, cochleariform process; FN, facial nerve; MFD, middle fossa dura; P, promontory; R, retractor; V, vestibule.

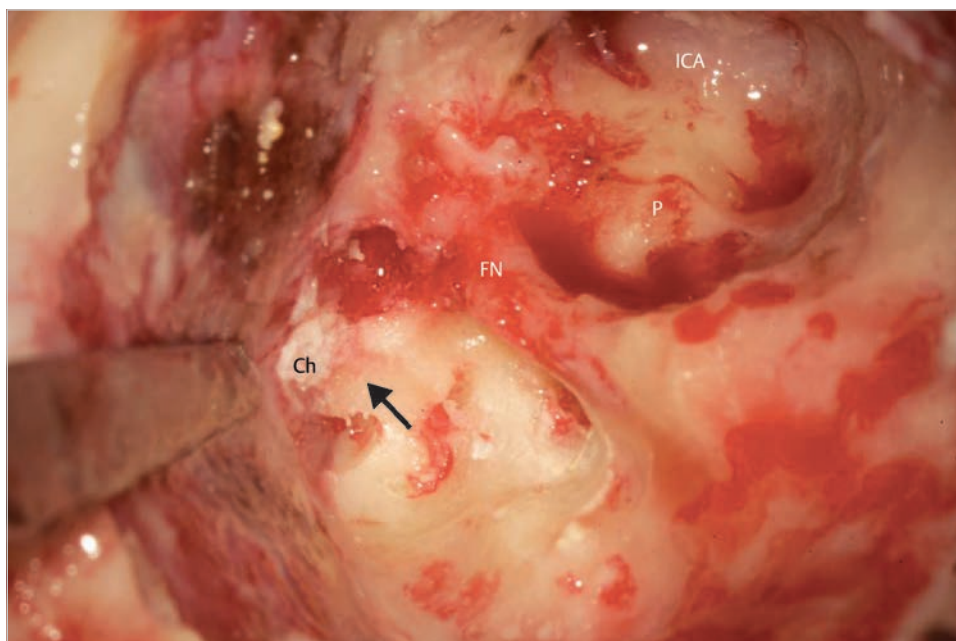


Fig. 14.61 Cholesteatoma extending medially beneath the middle fossa dura is shown. The bone covering cholesteatoma (*arrow*) should be removed without damaging the dura. Ch, cholesteatoma; FN, facial nerve; ICA, internal carotid artery; P, promontory.

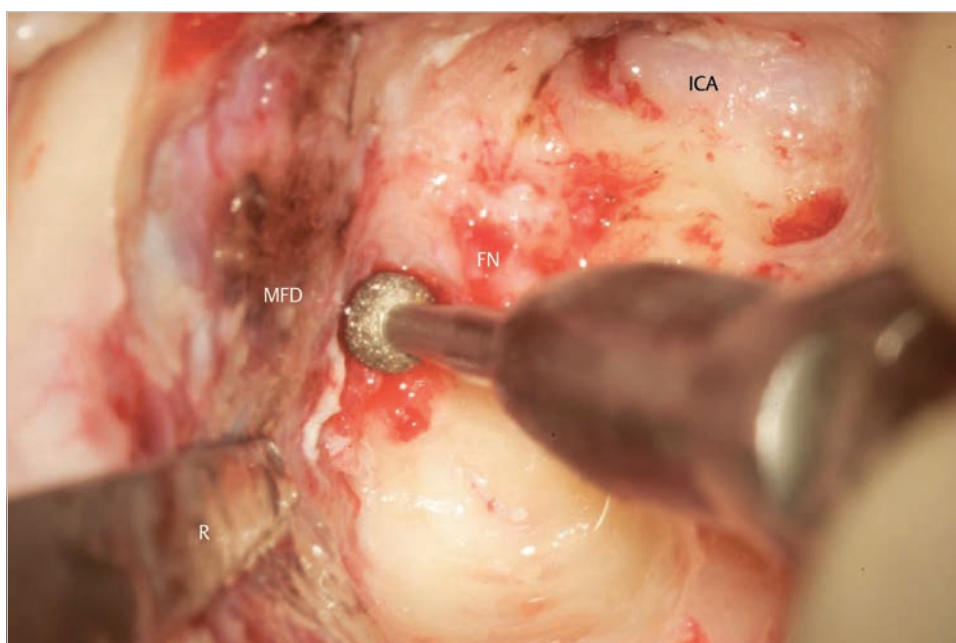


Fig. 14.62 The bone covering the final piece of cholesteatoma is drilled with a diamond burr. Use of small cutting burr is prohibited in this location because the dura is easily teared with a minor contact. FN, facial nerve; ICA, internal carotid artery; MFD, middle fossa dura; R, retractor.

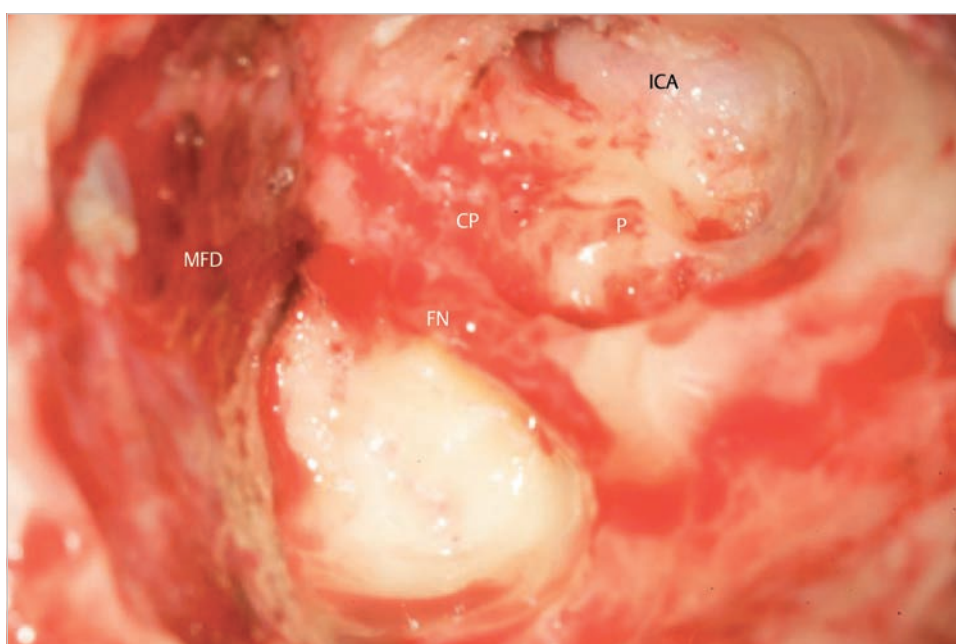


Fig. 14.63 Eradication of cholesteatoma is accomplished. The eustachian tube is closed with pieces of periosteum, and the cavity is packed with abdominal fat. CP, cochleariform process; FN, facial nerve; ICA, internal carotid artery; MFD, middle fossa dura; P, promontory.

Case 14.2 (Left Ear)

See ▶ Fig. 14.64, ▶ Fig. 14.65, ▶ Fig. 14.66, ▶ Fig. 14.67, ▶ Fig. 14.68, ▶ Fig. 14.69, ▶ Fig. 14.70, ▶ Fig. 14.71, ▶ Fig. 14.72, ▶ Fig. 14.73, ▶ Fig. 14.74, ▶ Fig. 14.75.

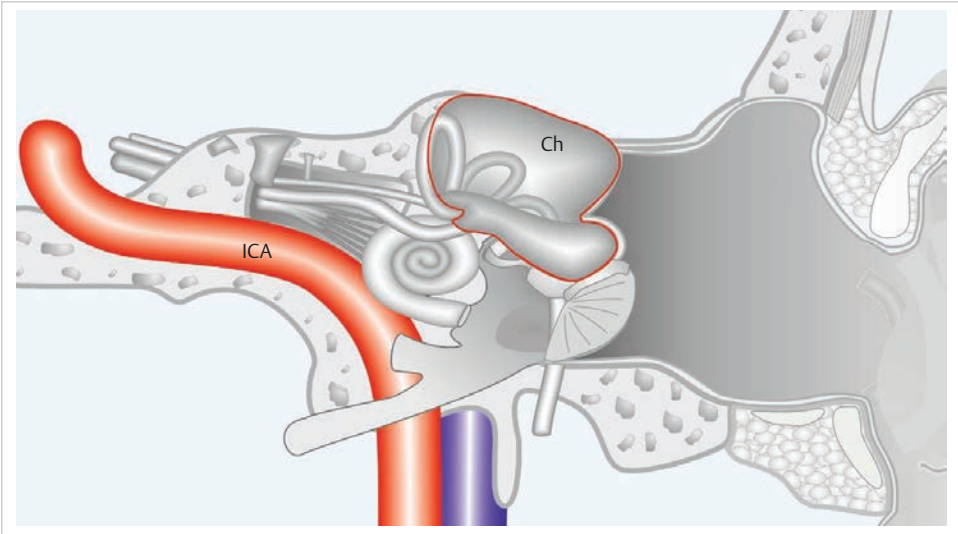


Fig. 14.64 A case of small residual supralabyrinthine petrous bone cholesteatoma after canal wall down tympanoplasty removed with translabyrinthine approach. The cholesteatoma erodes the posterior labyrinth. Ch, cholesteatoma; ICA, internal carotid artery.

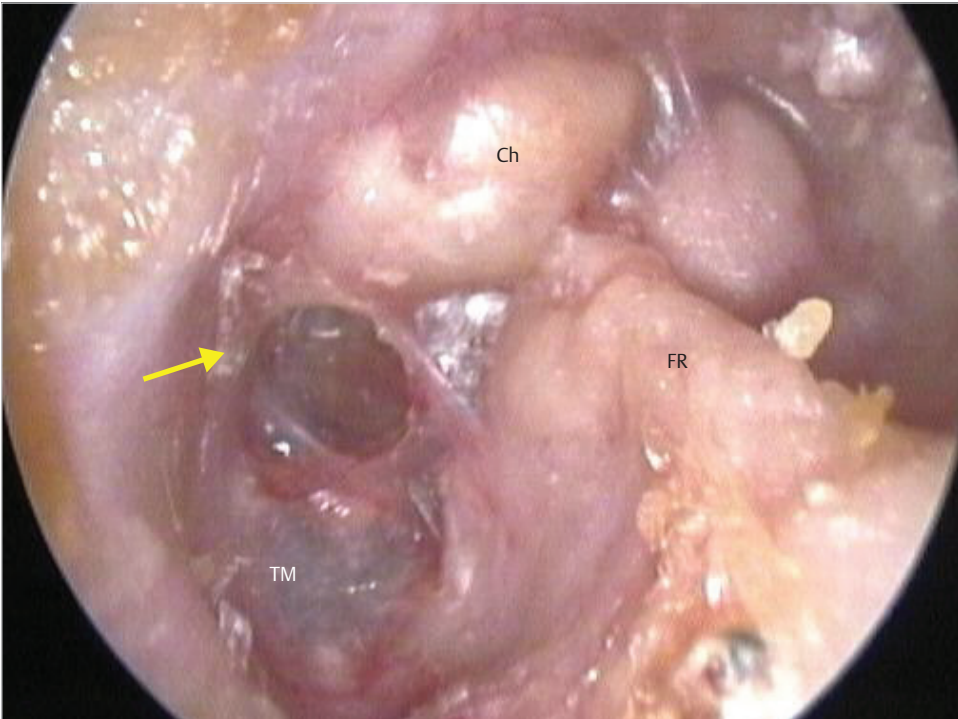


Fig. 14.65 The patient underwent cholesteatoma surgery with canal wall down technique elsewhere. Residual cholesteatoma (Ch) is seen at the tegmen of the cavity, just superior to the tympanic membrane. A deep dimple (arrow) is seen in the superior part of the tympanic membrane (TM). The facial ridge (FR) remains very high.

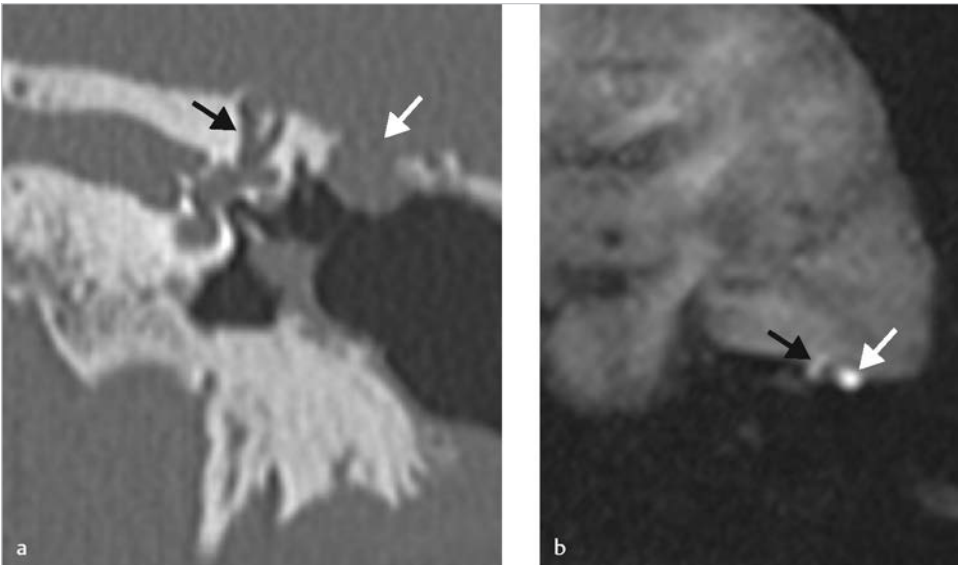


Fig. 14.66 The coronal CT (a) shows presence of soft tissue eroding the tegmen of the antrum (white arrow), infiltrating medially to the superior semicircular canal to erode its ampulla (black arrow). A coronal section of diffusion-weighted image of MRI (b) shows high signals in both area indicating presence of cholesteatoma.

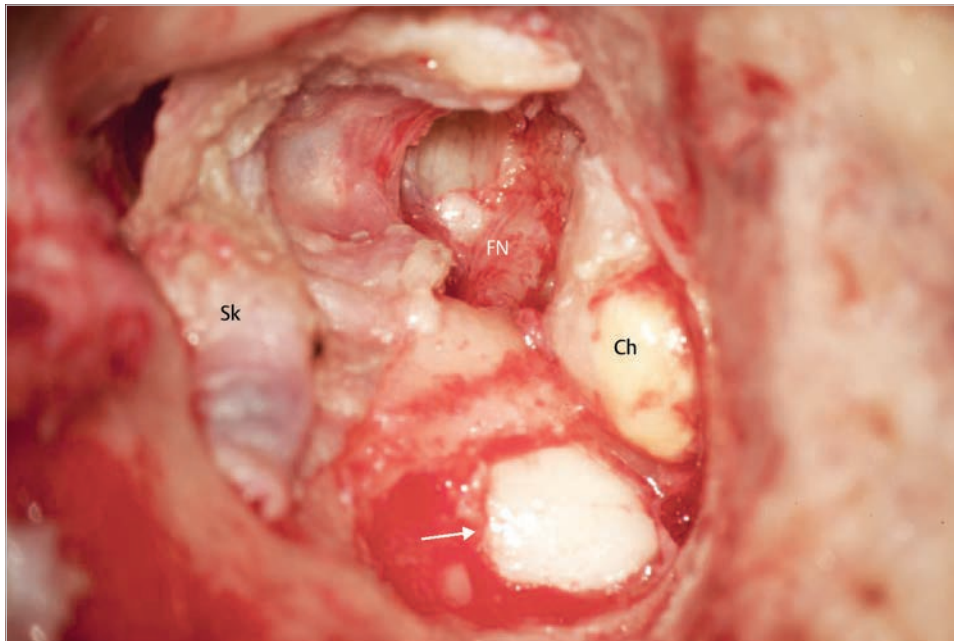


Fig. 14.67 The cavity is rounded by removing sharp bones from edges and lowering the facial ridge. The skin covering the cholesteatoma is detached to expose its lateral face. Note extensive exposure of the tympanic segment of the facial nerve. The whitish bulge posterior to the cholesteatoma (*arrow*) is newly formed bone. Ch, cholesteatoma; FN, facial nerve; Sk, skin.

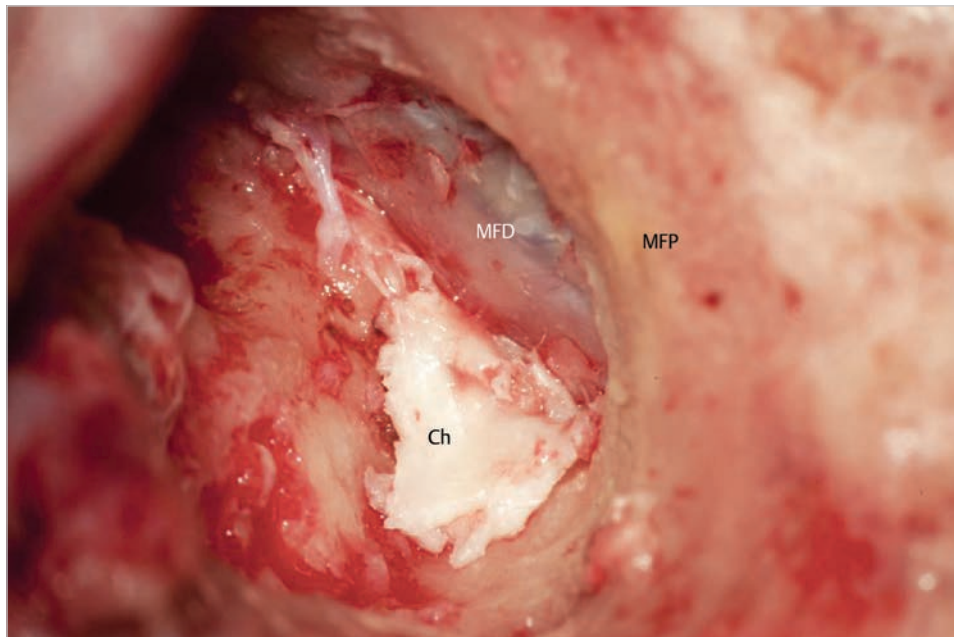


Fig. 14.68 Dissection of cholesteatoma from the tegmen revealed extensive exposure of the middle fossa dura. Ch, cholesteatoma; MFD, middle fossa dura; MFP, middle fossa plate.

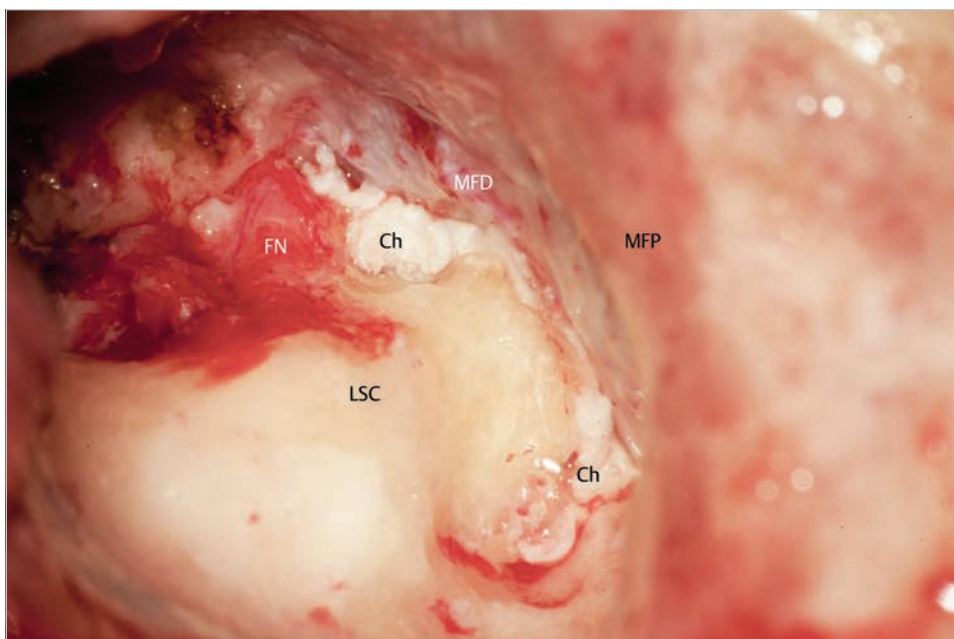


Fig. 14.69 Drilling to remove the bone covering cholesteatoma is advanced medially. The matrix infiltrates the bone under the dura and goes medially to the superior semicircular canal. In this particular case, the most lateral part of the middle fossa plate is not removed due to limited extension of the pathology. This lateral part must be removed if there is some difficulty in the following cholesteatoma removal. Ch, cholesteatoma; FN, facial nerve; LSC, lateral semicircular canal; MFD, middle fossa dura; MFP, middle fossa plate.

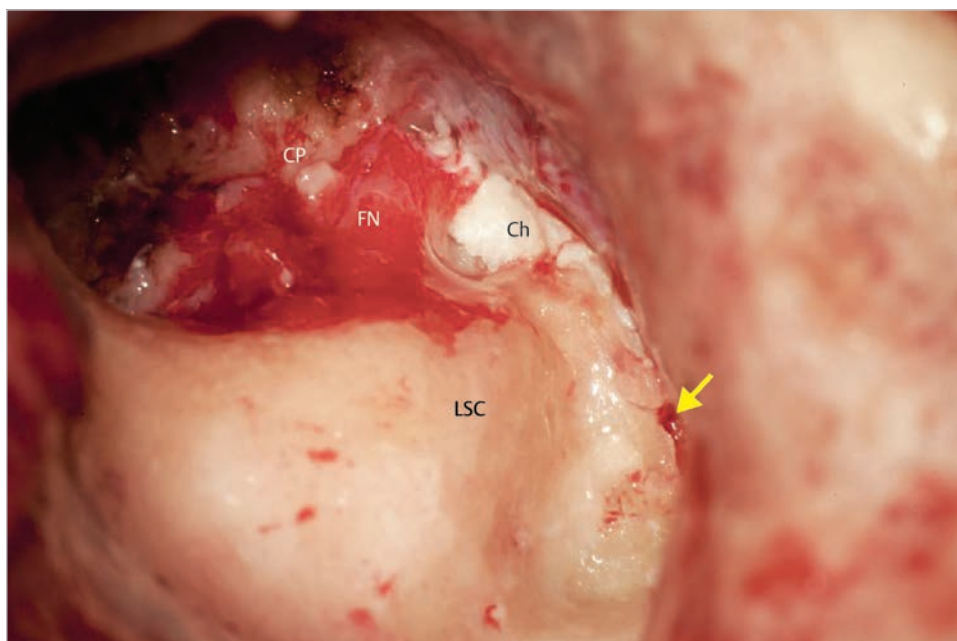


Fig. 14.70 The superior semicircular canal is opened (*arrow*) to remove the matrix advanced medially to the anterior part of the canal. The tympanic segment of the facial nerve courses just superiorly to the cochleariform process. Ch, cholesteatoma; CP, cochleariform process; FN, facial nerve; LSC, lateral semicircular canal.

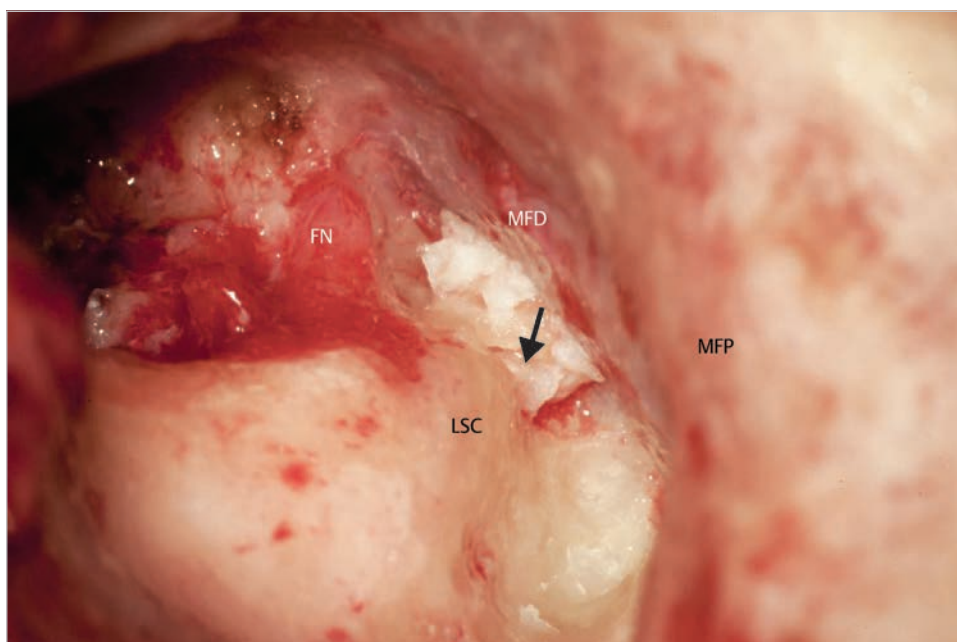


Fig. 14.71 The superior semicircular canal is removed to expose cholesteatoma infiltrating the ampulla of the superior semicircular canal (*arrow*). The final part of cholesteatoma remains in the medial wall of the attic. FN, facial nerve; MFD, middle fossa dura; MFP, middle fossa plate; LSC, lateral semicircular canal.

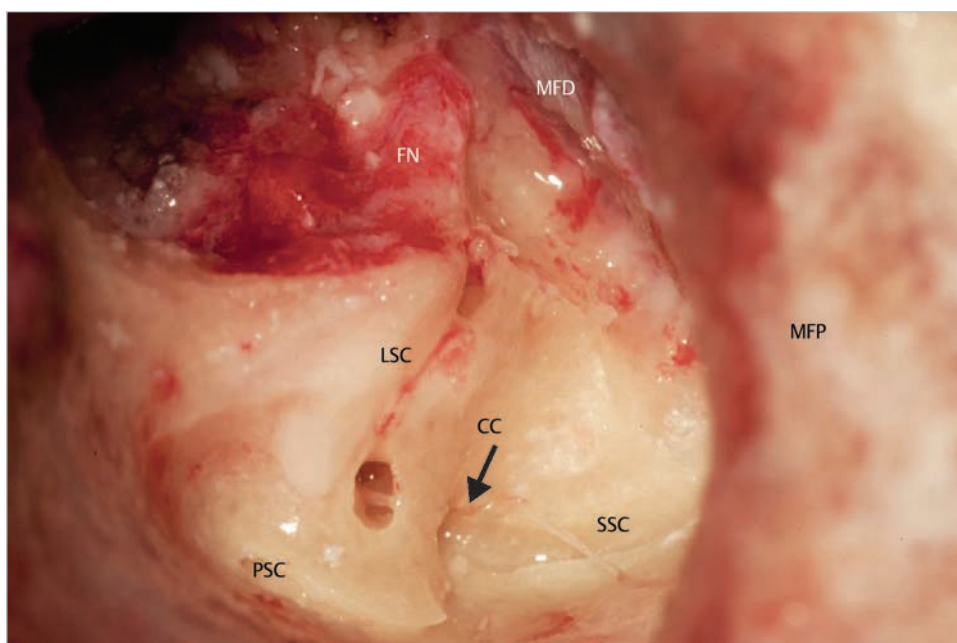


Fig. 14.72 The lateral and the posterior semicircular canals are drilled, and cholesteatoma is eradicated from the attic. CC, common crus; FN, facial nerve; LSC, lateral semicircular canal; MFD, middle fossa dura; MFP, middle fossa plate; PSC, posterior semicircular canal; SSC, superior semicircular canal.

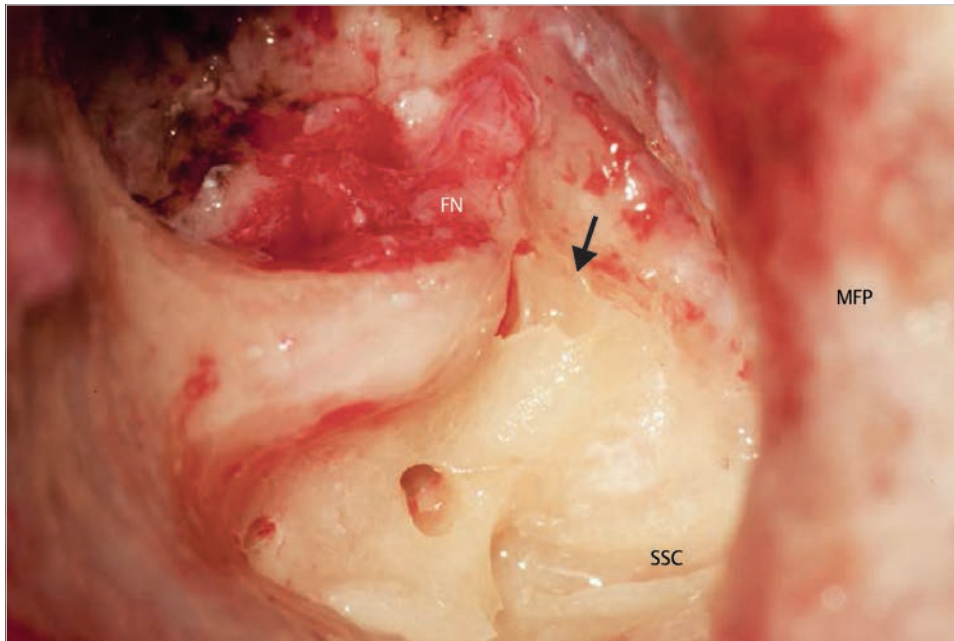


Fig. 14.73 The lateral and the posterior semicircular canals are further drilled. Two ampullae of the lateral and the superior semicircular canals are opened. The arrow points the boundary between the ampulla of the superior semicircular canal and the cholesteatoma. FN, facial nerve; MFP, middle fossa plate; SSC, superior semicircular canal.

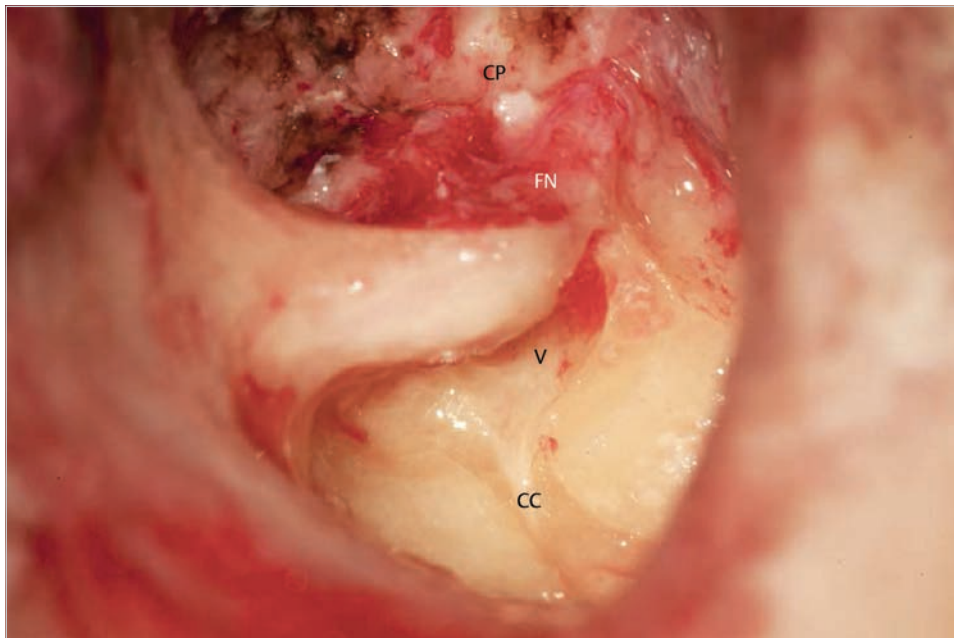


Fig. 14.74 The vestibule is opened, and the membranous labyrinth is removed to accomplish labyrinthectomy. After closing the eustachian tube with periosteum, the cavity is obliterated with abdominal fat. CC, common crus; CP, cochleariform process; FN, facial nerve; V, vestibule.

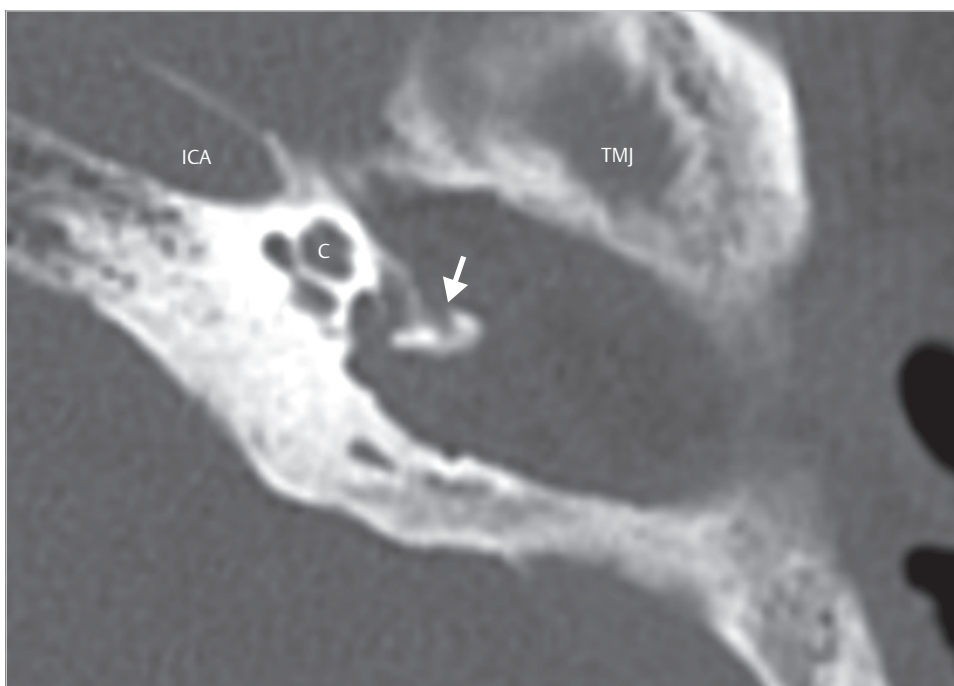


Fig. 14.75 The postoperative CT demonstrates removal of the posterior labyrinth with preservation of the facial nerve (arrow). C, cochlea; ICA, internal carotid artery; TMJ, temporomandibular joint.

Case 14.3 (Right Ear)

See ▶ Fig. 14.76, ▶ Fig. 14.77, ▶ Fig. 14.78, ▶ Fig. 14.79, ▶ Fig. 14.80, ▶ Fig. 14.81, ▶ Fig. 14.82, ▶ Fig. 14.83, ▶ Fig. 14.84, ▶ Fig. 14.85, ▶ Fig. 14.86, ▶ Fig. 14.87, ▶ Fig. 14.88, ▶ Fig. 14.89, ▶ Fig. 14.90, ▶ Fig. 14.91, ▶ Fig. 14.92, ▶ Fig. 14.93.

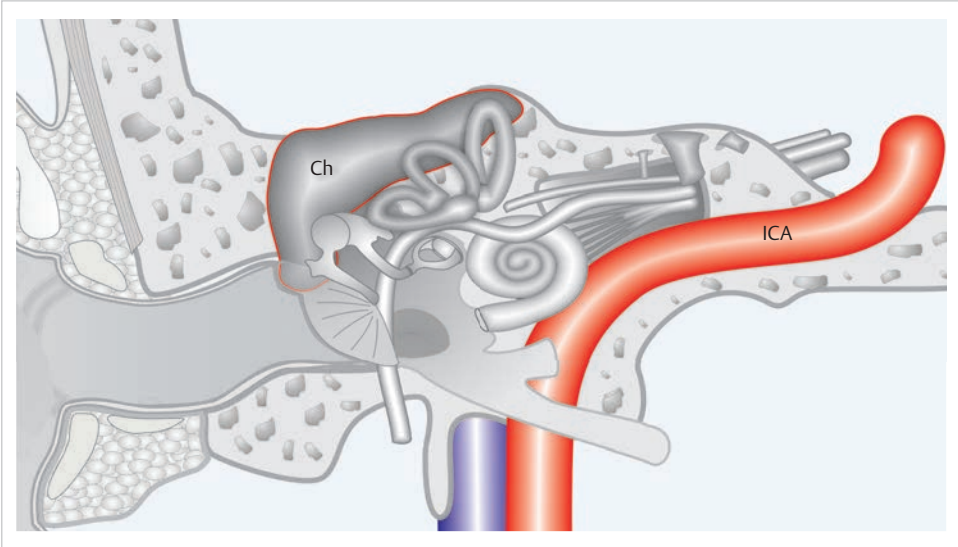


Fig. 14.76 A case of small congenital supralabyrinthine petrous bone cholesteatoma removed with transabyrinthine approach. Both the superior and the lateral semicircular canals are eroded. Ch, cholesteatoma; ICA, internal carotid artery.

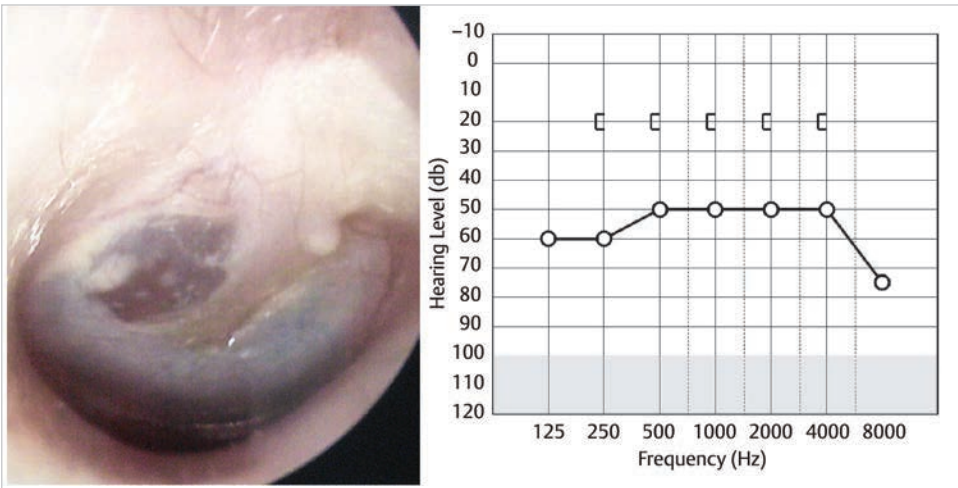


Fig. 14.77 Otoscopy (*left*) shows whitish bulging in the area of the attic, with no evidence of retraction pocket. The pars tensa remains intact except a thin scar in the posterosuperior quadrant. The preoperative audiogram shows air–bone gap of 30 dB with normal bone conduction.

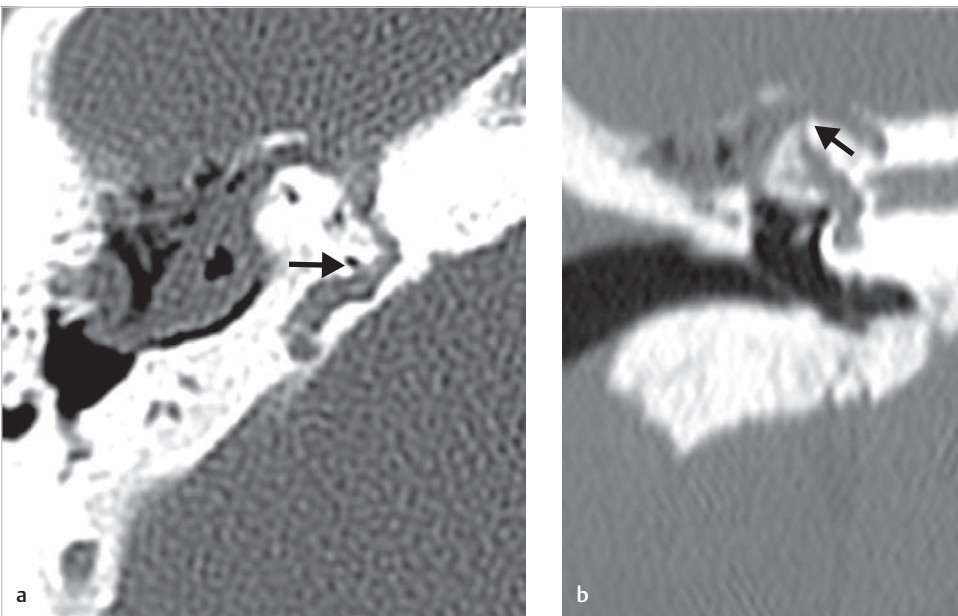


Fig. 14.78 Both the axial (**a**) and the coronal (**b**) CT demonstrated extension of cholesteatoma medially to the superior semicircular canal. A labyrinthine fistula is identified in the canal (*black arrows*). Extensive erosion of the tegmen is seen in the coronal section.

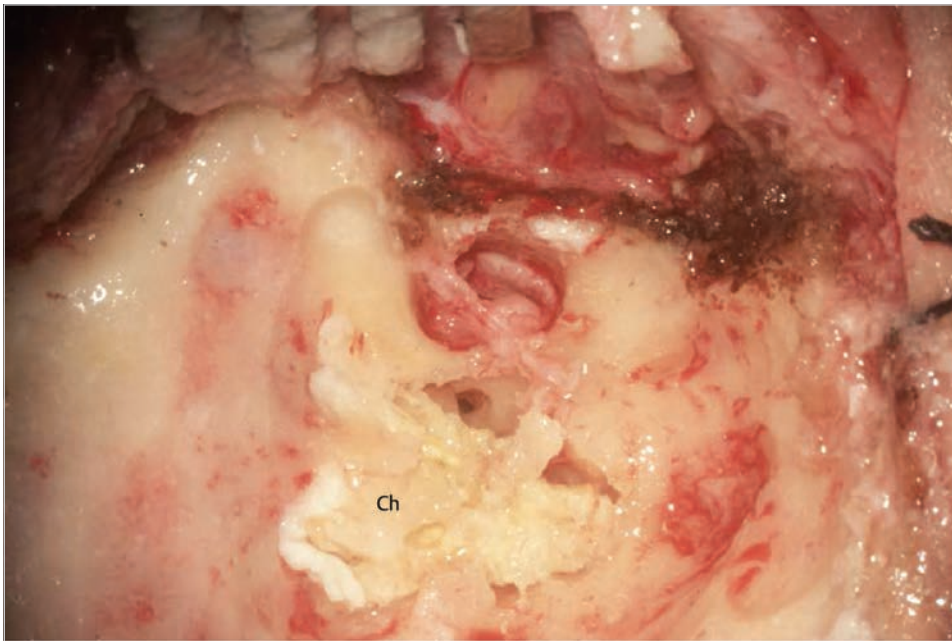


Fig. 14.79 After closing the external auditory canal, a mastoidectomy is carried out to expose cholesteatoma filling the mastoid. Ch, cholesteatoma.

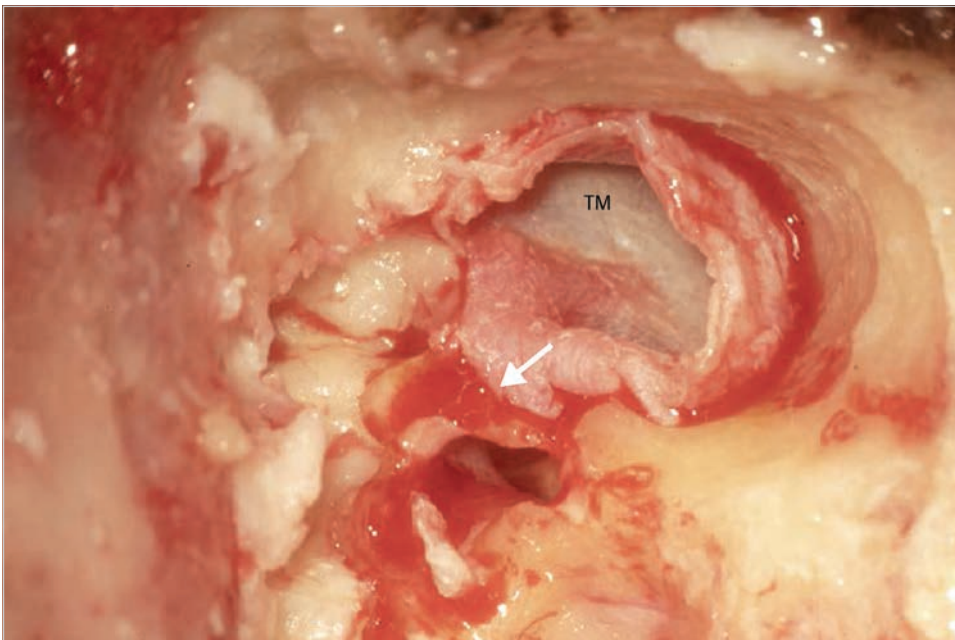


Fig. 14.80 The cholesteatoma filling the attic behind the intact tympanic membrane is shown. The incus with moderate bone erosion is seen (arrow). TM, tympanic membrane.

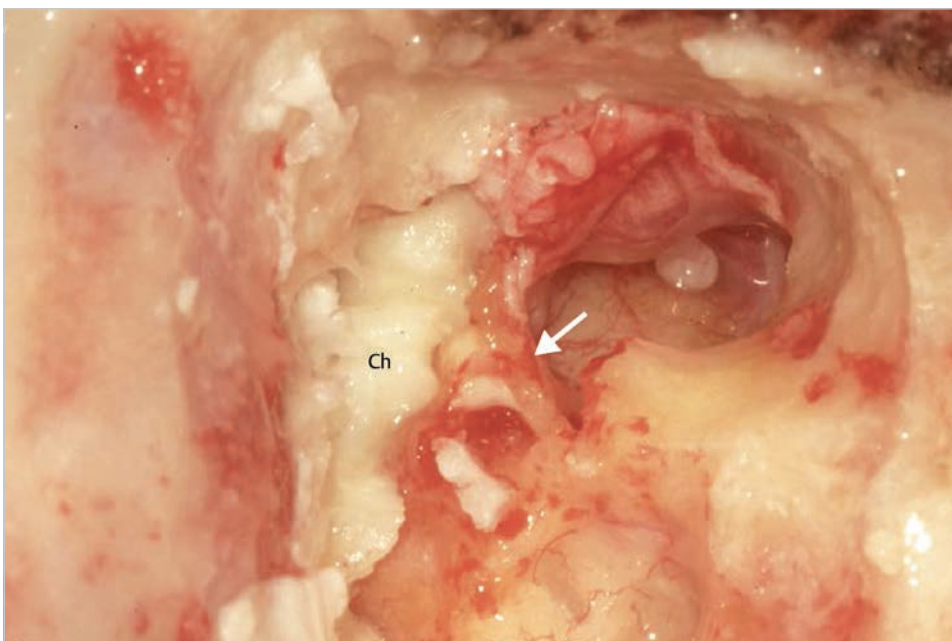


Fig. 14.81 The tympanic membrane is reflected anteriorly, and the tympanic cavity is opened. The cholesteatoma shows limited extension to the mesotympanum. The cholesteatoma located medially to the remnant of the incus (arrow) is seen. Ch, cholesteatoma.

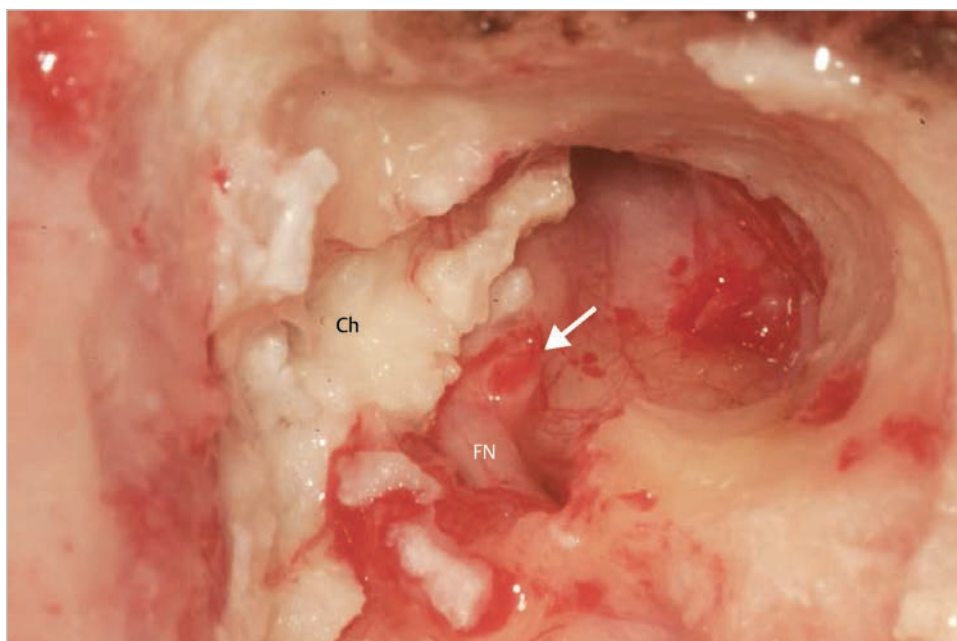


Fig. 14.82 The tendon of the tensor tympani muscle is cut, and the tympanomeatal flap is removed with the malleus. The facial nerve coursing just superiorly to the cochleariform process (*arrow*) is seen. Ch, cholesteatoma; FN, facial nerve.

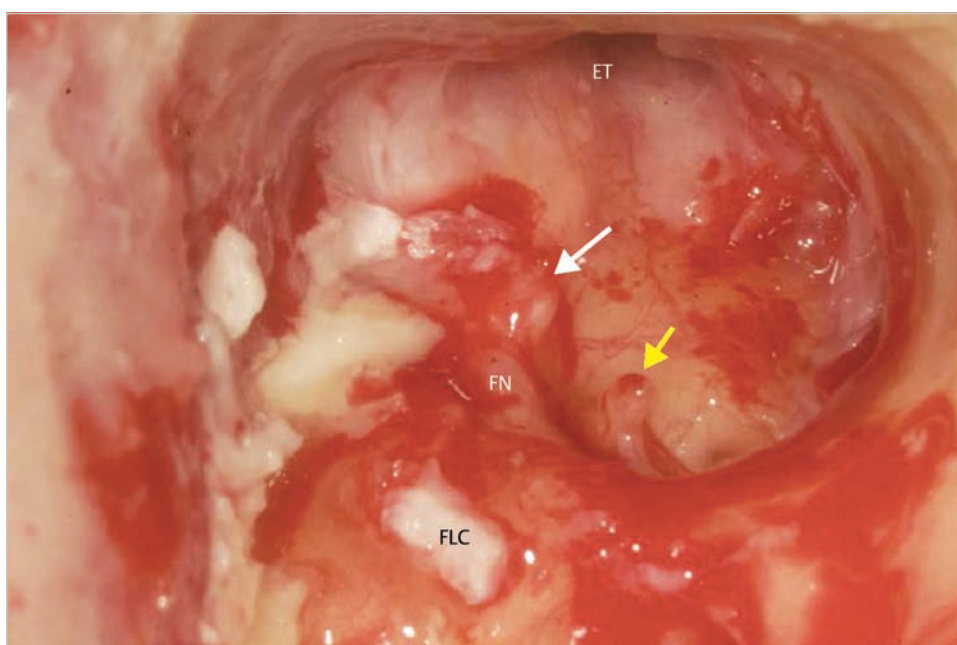


Fig. 14.83 The facial ridge is lowered, and removal of cholesteatoma from the attic is started. Note the relationship between the cochleariform process (*white arrow*) and the facial nerve. The superstructure of the stapes (*yellow arrow*) is seen posteriorly to the process, just under the facial nerve. A labyrinthine fistula is seen in the lateral semicircular canal. ET, eustachian tube; FLC, fistula in lateral semicircular canal; FN, facial nerve.

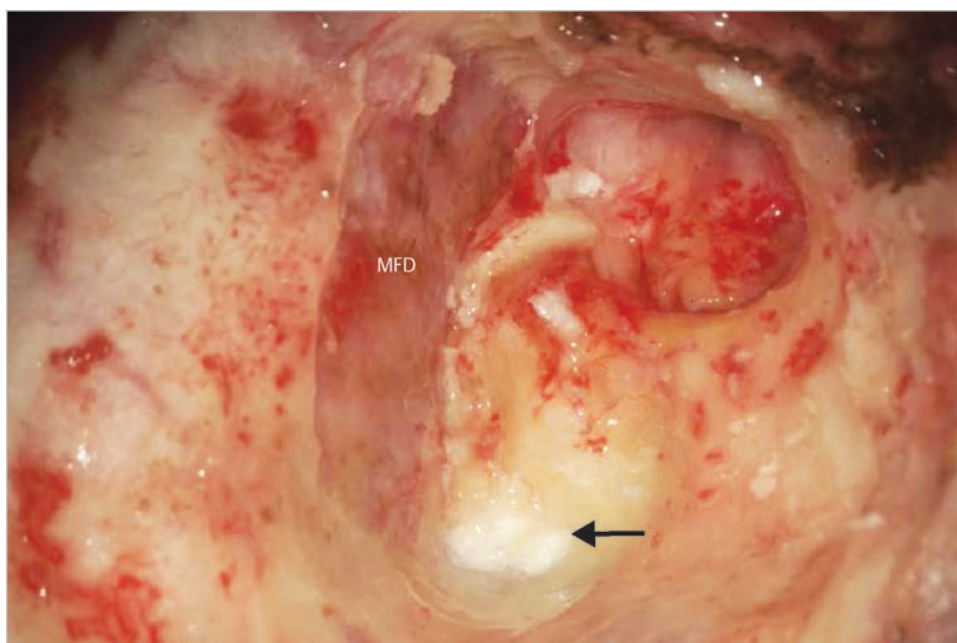


Fig. 14.84 The cholesteatoma infiltrates the cells between the middle fossa plate and the otic capsule to reach the area medial to the superior semicircular canal. The sinodural angle (*arrow*) is also occupied by the cholesteatoma. The middle fossa dura (MFD) is exposed to enlarge access to the cholesteatoma.

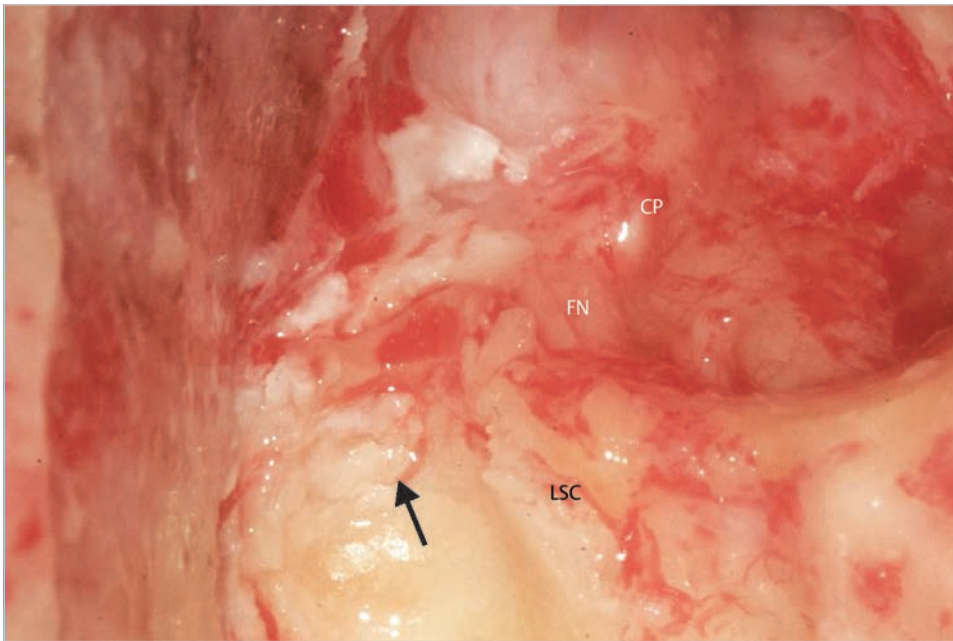


Fig. 14.85 A labyrinthectomy is started. The cholesteatoma infiltrating the ampulla of the superior semicircular canal is shown (*arrow*). CP, cochleariform process; FN, facial nerve; LSC, lateral semicircular canal.

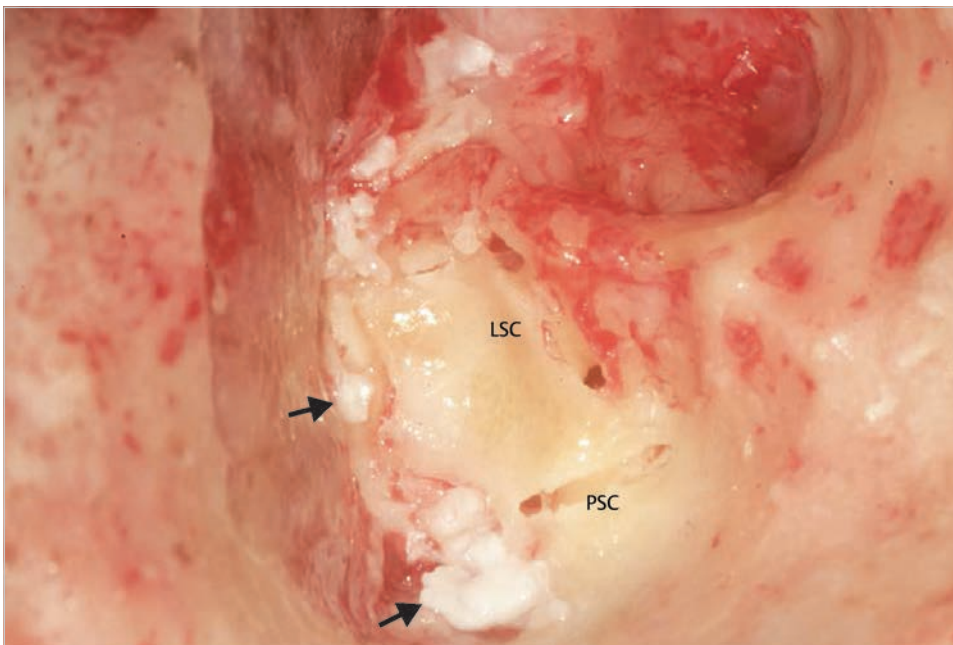


Fig. 14.86 The lateral and the posterior semicircular canals are opened. The cholesteatoma ingrowing medially to the labyrinth is visualized (*arrows*). LSC, lateral semicircular canal; PSC, posterior semicircular canal.

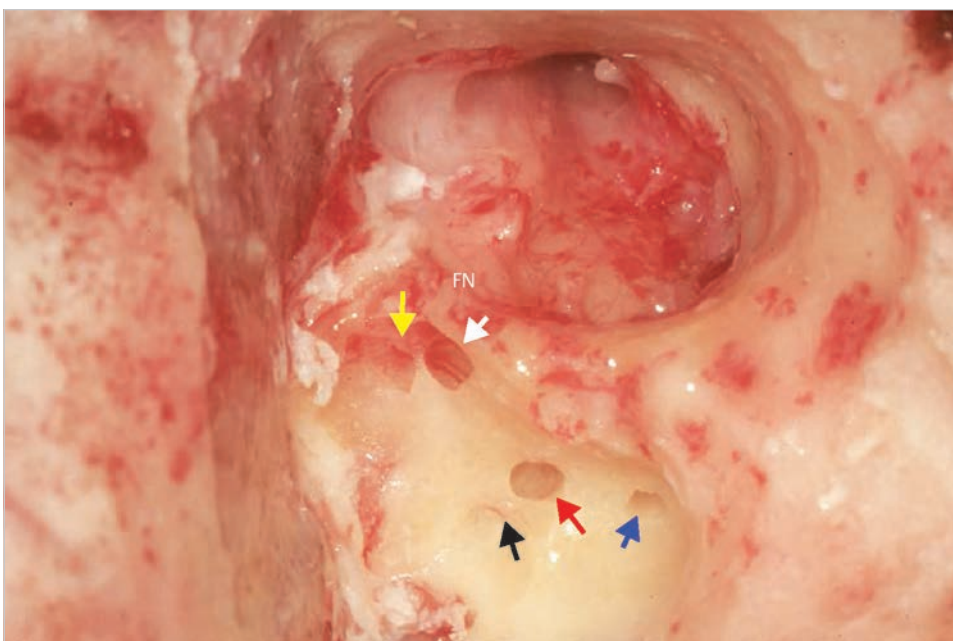


Fig. 14.87 The labyrinthectomy is advanced medially. At the posterior end of the lateral semicircular canal, an opening of the vestibule is seen (*red arrow*). The common crus is located just posterosuperior to it (*black arrow*). The ampullae of the lateral (*white arrow*) and the superior (*yellow*) semicircular canals, and inferior stump of the posterior semicircular canal (*blue arrow*) are identified. FN, facial nerve.

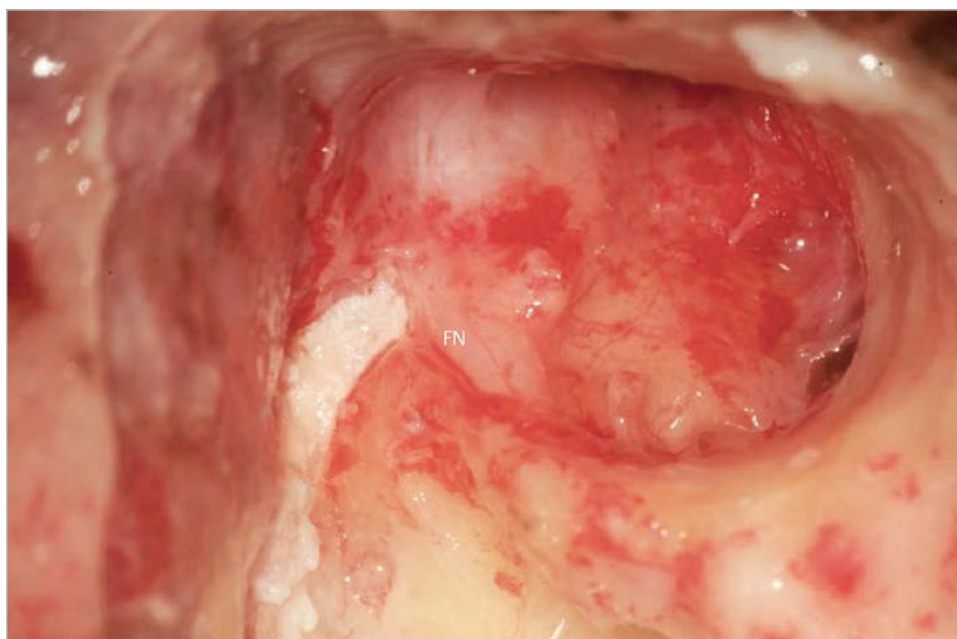


Fig. 14.88 The labyrinthectomy visualized the cholesteatoma infiltrating the medial wall of the attic. FN, facial nerve.

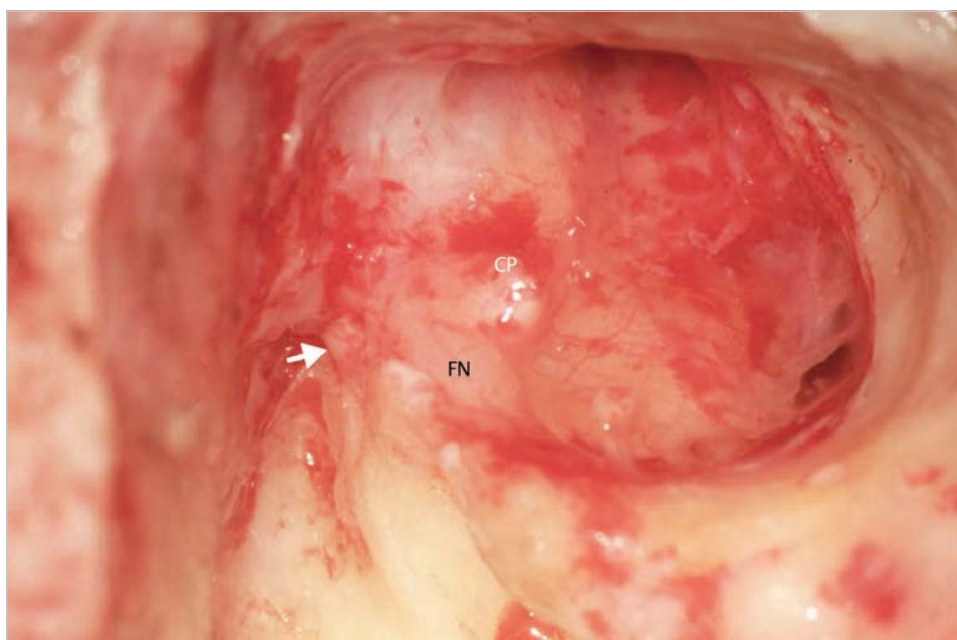


Fig. 14.89 Removal of cholesteatoma from the attic is accomplished. The arrow indicates the exposed labyrinthine segment of the facial nerve. Note the relationships between the facial nerve and the cochleariform process. CP, cochleariform process; FN, facial nerve.



Fig. 14.90 The labyrinthectomy is completed. The cholesteatoma is eradicated from the temporal bone. ET, eustachian tube.

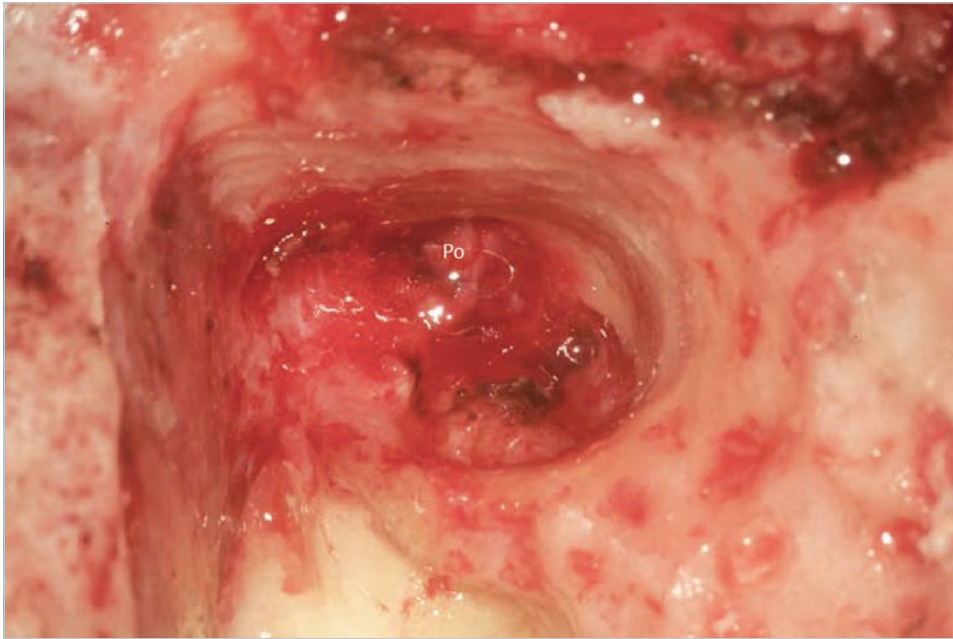


Fig. 14.91 The eustachian tube is obliterated with pieces of periosteum. Po, periosteum.

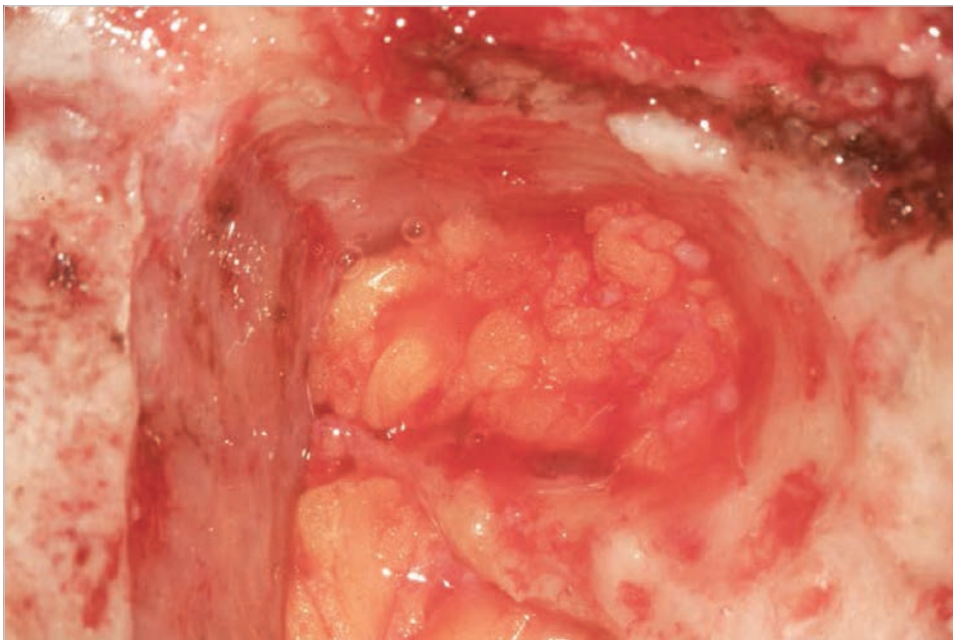


Fig. 14.92 The cavity is obliterated with abdominal fat.

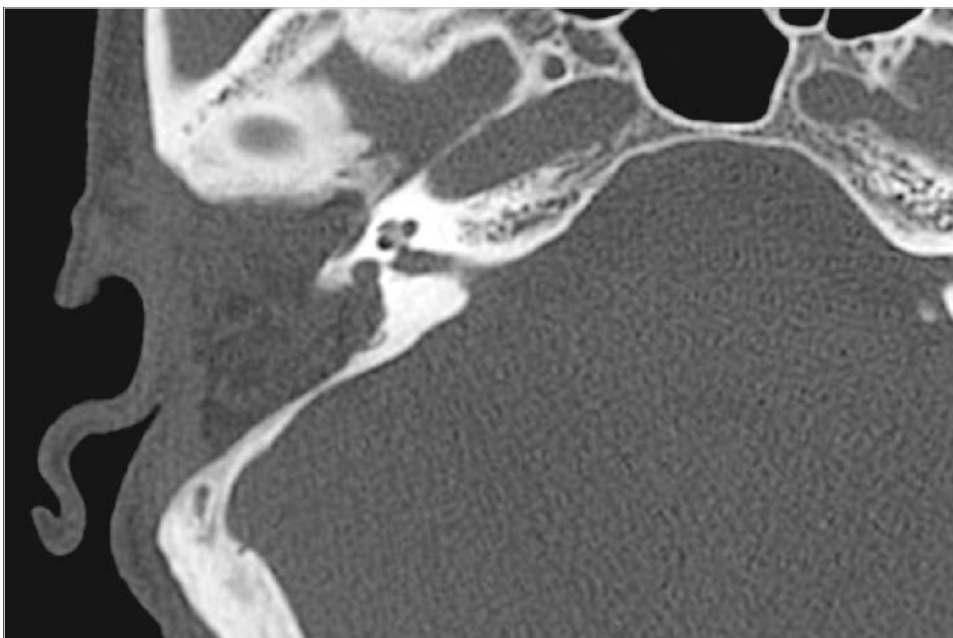


Fig. 14.93 The postoperative CT shows complete removal of the posterior labyrinth. Because of limited extension of the cholesteatoma, thin bone covering the posterior fossa dura is remained at this level.

Case 14.4 (Right Ear)

See ▶ Fig. 14.94, ▶ Fig. 14.95, ▶ Fig. 14.96, ▶ Fig. 14.97, ▶ Fig. 14.98, ▶ Fig. 14.99, ▶ Fig. 14.100, ▶ Fig. 14.101, ▶ Fig. 14.102, ▶ Fig. 14.103,

▶ Fig. 14.104, ▶ Fig. 14.105, ▶ Fig. 14.106, ▶ Fig. 14.107, ▶ Fig. 14.108, ▶ Fig. 14.109, ▶ Fig. 14.110, ▶ Fig. 14.111, ▶ Fig. 14.112, ▶ Fig. 14.113, ▶ Fig. 14.114, ▶ Fig. 14.115, ▶ Fig. 14.116, ▶ Fig. 14.117, ▶ Fig. 14.118, ▶ Fig. 14.119, ▶ Fig. 14.120.

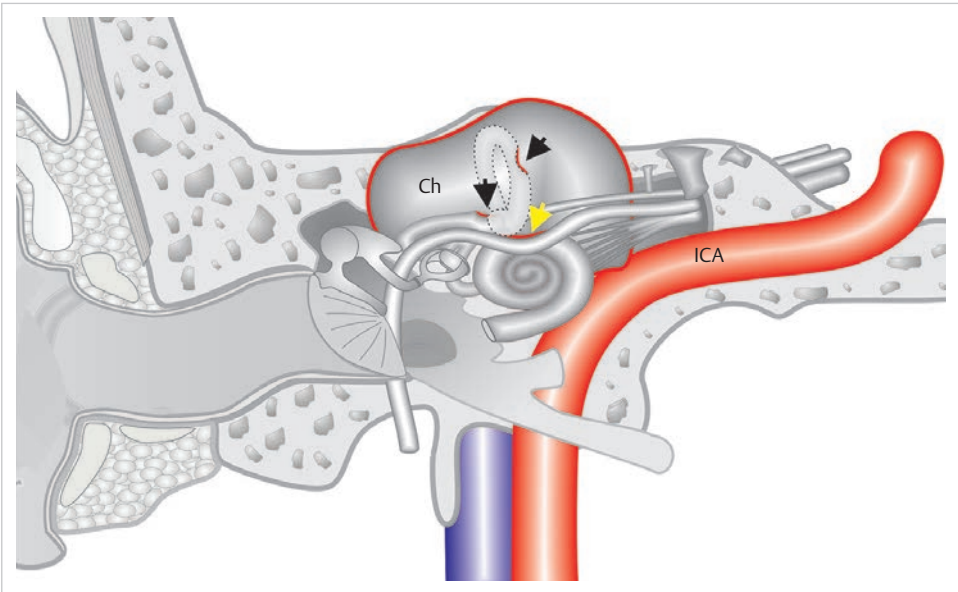


Fig. 14.94 A case of congenital supralabyrinthine petrous bone cholesteatoma removed with transotic approach. The cholesteatoma erodes the superior and the lateral semicircular canals, and the cholesteatoma also erodes the superior face of the cochlea to push the facial nerve laterally. Ch, cholesteatoma; ICA, internal carotid artery.

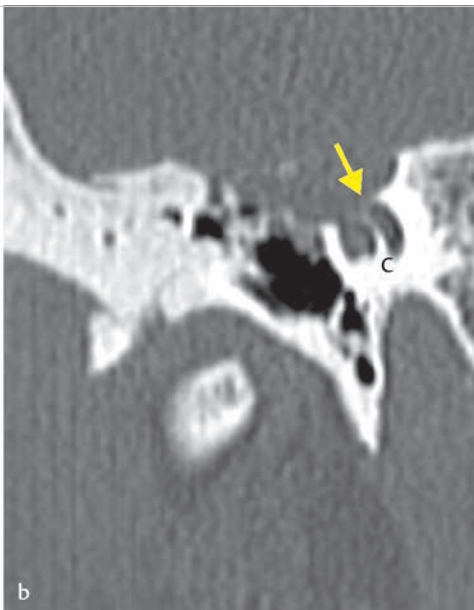
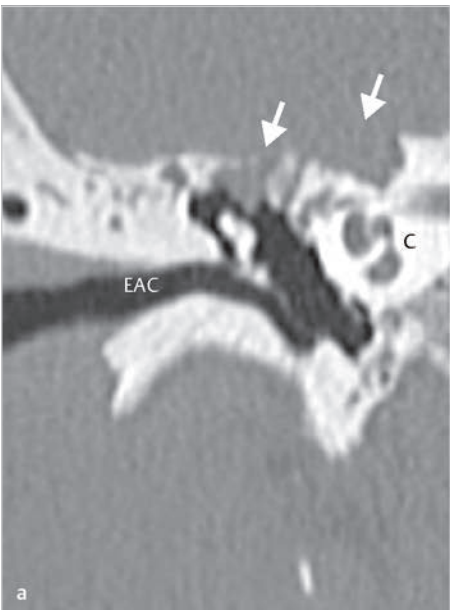


Fig. 14.95 The coronal CT (a) at the level of the head of the malleus shows that the cholesteatoma eroding the middle fossa plate (white arrows) has no relationships with the intact tympanic membrane. The more anterior slice (b) shows severe erosion of the cochlea (yellow arrow) and involvement of the facial nerve located just superiorly to it. C, cochlea; EAC, external auditory canal.

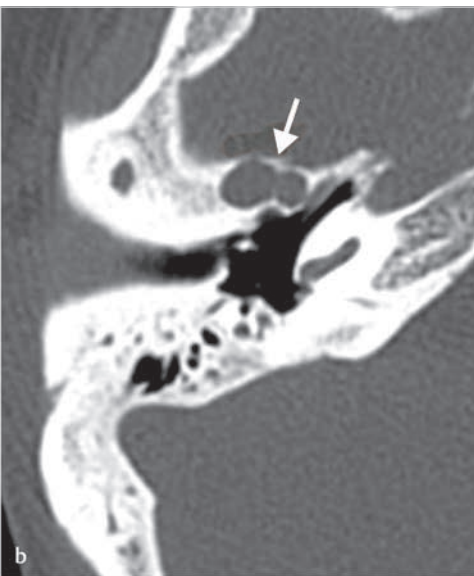


Fig. 14.96 The axial CT (a) shows infiltration of the cholesteatoma to the superior semicircular canal (black arrow) reaching the area close to the fundus of the internal auditory canal (red arrow). The CT at the level of the basal turn of the cochlea (b) shows anterior extension of cholesteatoma (white arrow) without involving the mesotympanum.

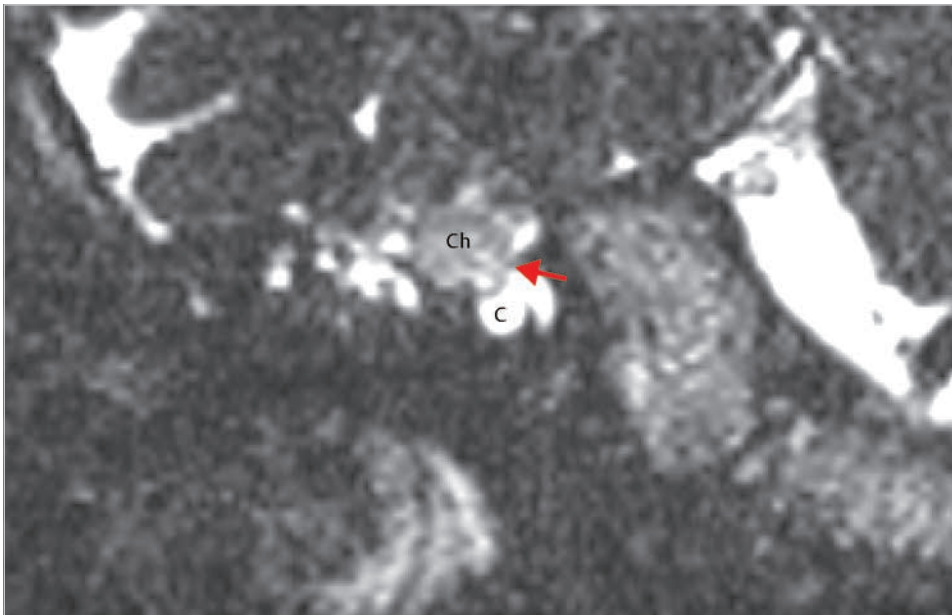


Fig. 14.97 The coronal image of preoperative MRI of heavily T2-weighted image demonstrates cochlear infiltration (*arrow*) by the cholesteatoma. C, cochlea; Ch, cholesteatoma.

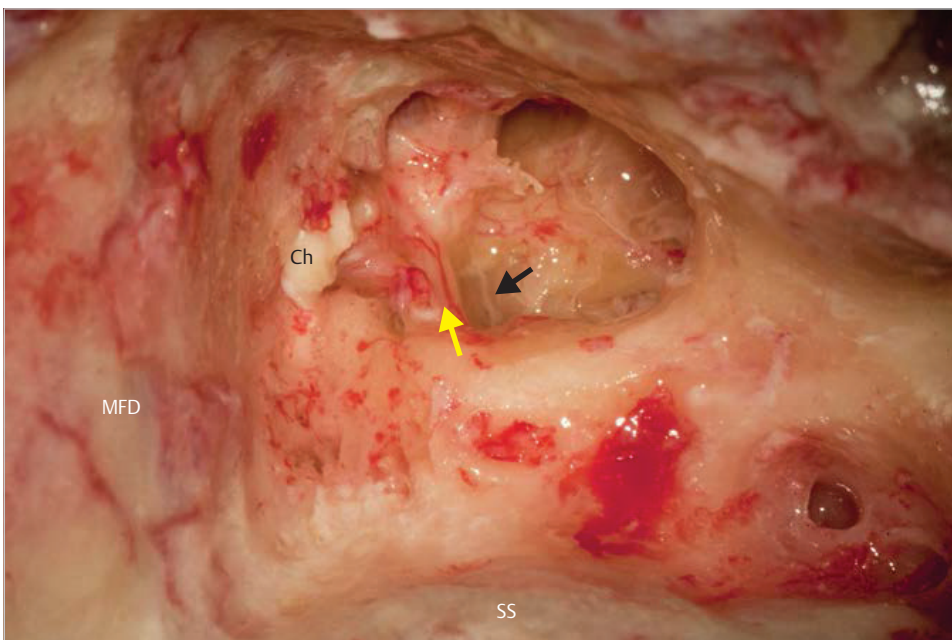


Fig. 14.98 Canal wall down mastoidectomy is completed, and the middle fossa dura and the sigmoid sinus are skeletonized. The meatal skin and the tympanic membrane are removed with the ossicular chain including the stapes. The tympanic cavity is free of disease. The oval window (*black arrow*) is seen under the tympanic segment of the facial nerve (*yellow arrow*). The most lateral part of the cholesteatoma in the attic is partially removed. Ch, cholesteatoma; MFD, middle fossa dura; SS, sigmoid sinus.

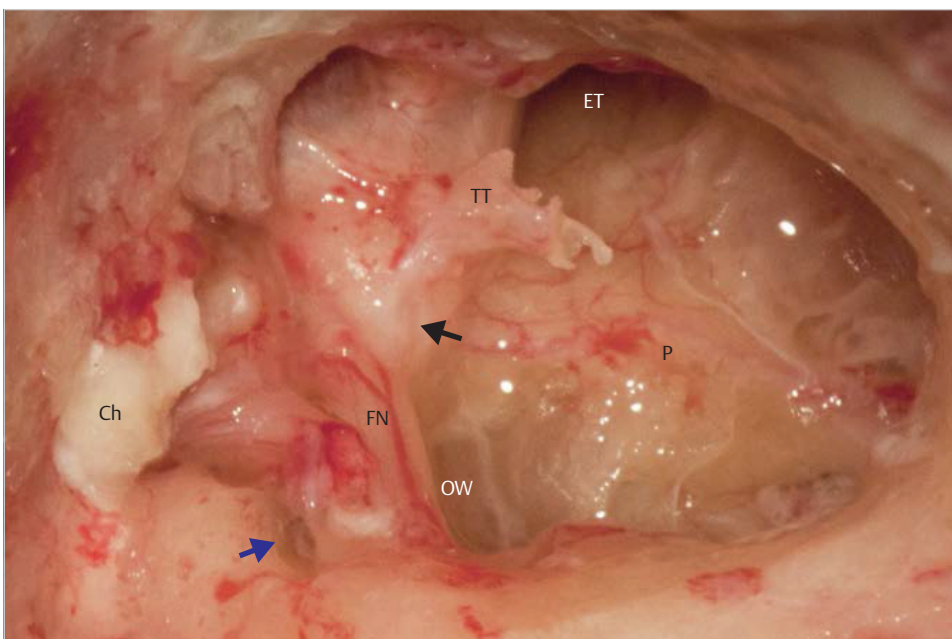


Fig. 14.99 In higher magnification, structures of the medial wall of the middle ear are clearly identified. The tympanic segment of the facial nerve is exposed. The labyrinthine fistula is present at the level of the ampulla of the lateral semicircular canal (*blue arrow*). The oval window after removing the stapes is seen. The cholesteatoma infiltrates medial wall of the attic. Ch, cholesteatoma; ET, eustachian tube; FN, facial nerve; TT, tendon of tensor tympani muscle; OW, oval window; P, promontory.

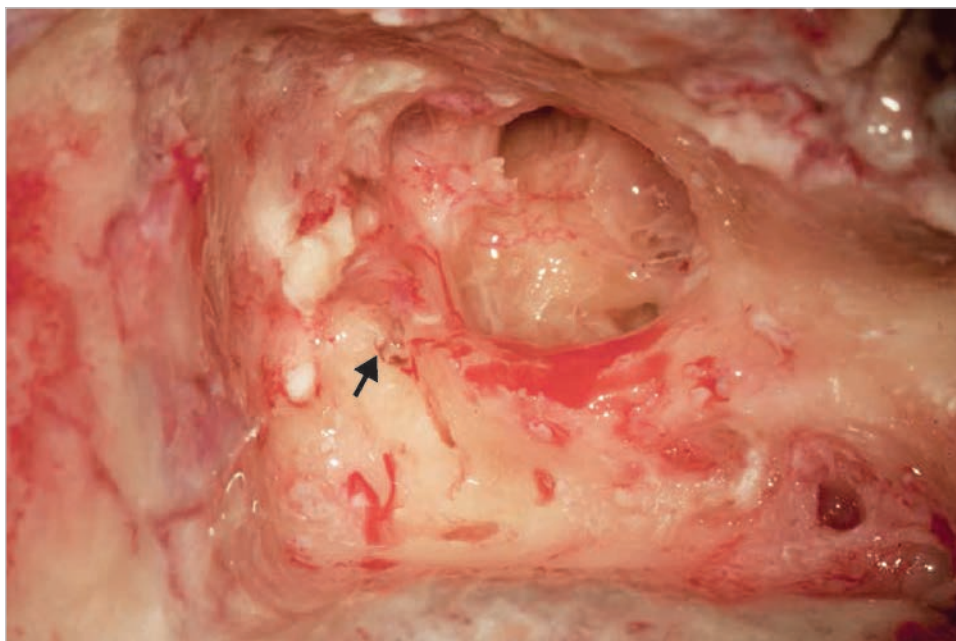


Fig. 14.100 The drilling is advanced posteriorly to expose cholesteatoma located medially to the labyrinth. The lateral semicircular canal is opened, and the ampulla located at the anterior end of the semicircular canal is seen (arrow).

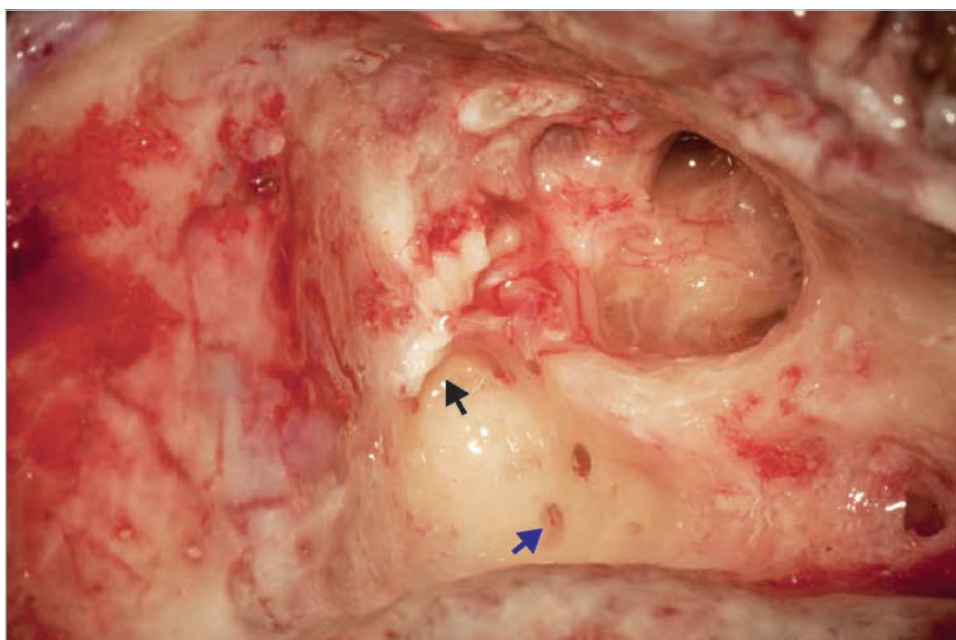


Fig. 14.101 Drilling of the superior semicircular canal revealed erosion of the canal by the cholesteatoma (black arrow). The posterior semicircular canal is also drilled to reach its superior end (blue arrow).

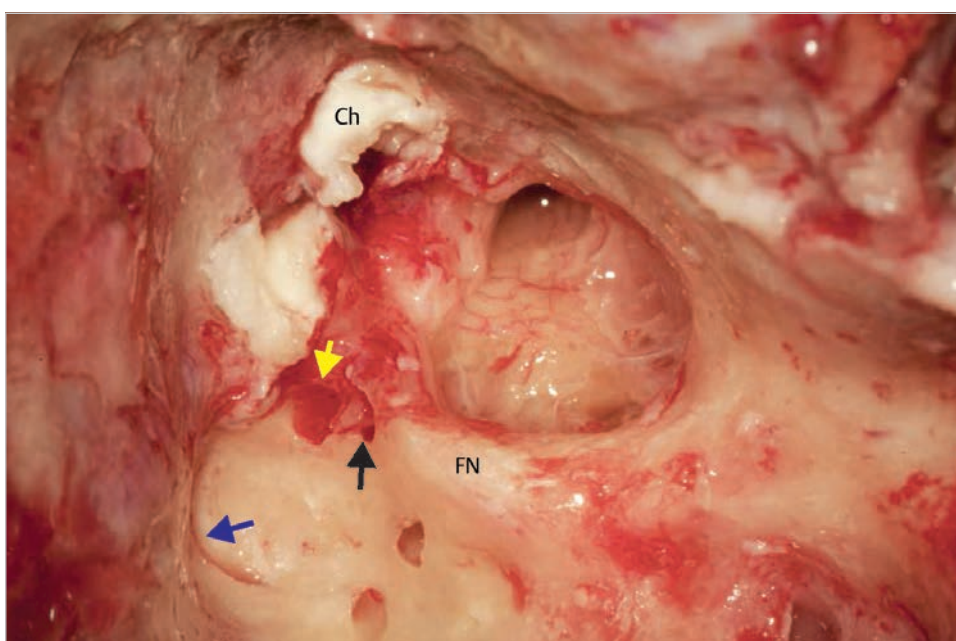


Fig. 14.102 The drilling is advanced medially and anteriorly. The cholesteatoma infiltrates the supratubal recess. Ampullae of the lateral (black arrow) and the superior (yellow arrow) semicircular canals are opened. The superior semicircular canal (blue arrow) is identified near the middle fossa dura. Ch, cholesteatoma; FN, facial nerve.

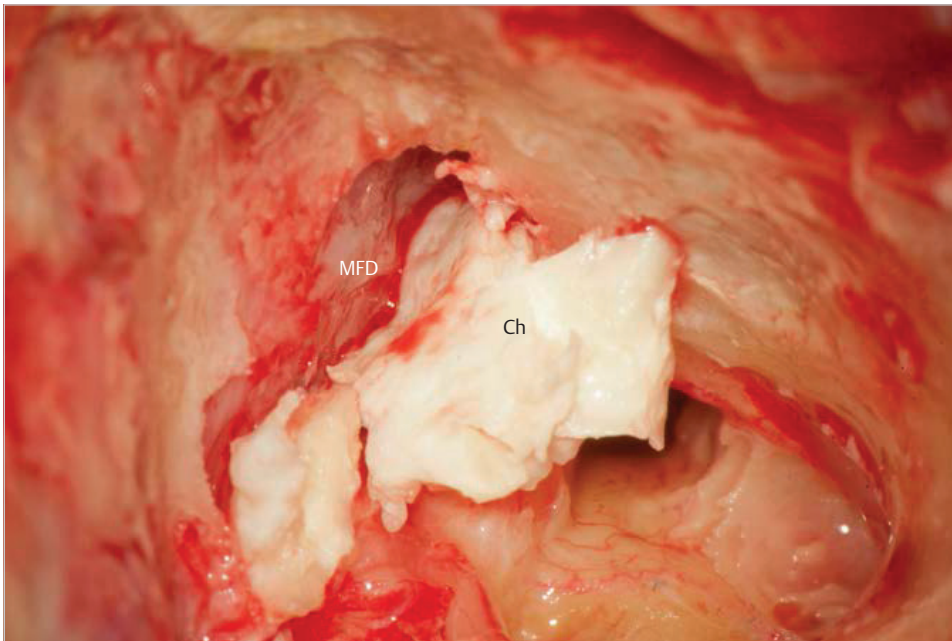


Fig. 14.103 The dissection of the matrix from the middle fossa dura is advanced anteriorly to reach the area of the supratubal recess. Ch, cholesteatoma; MFD, middle fossa dura.

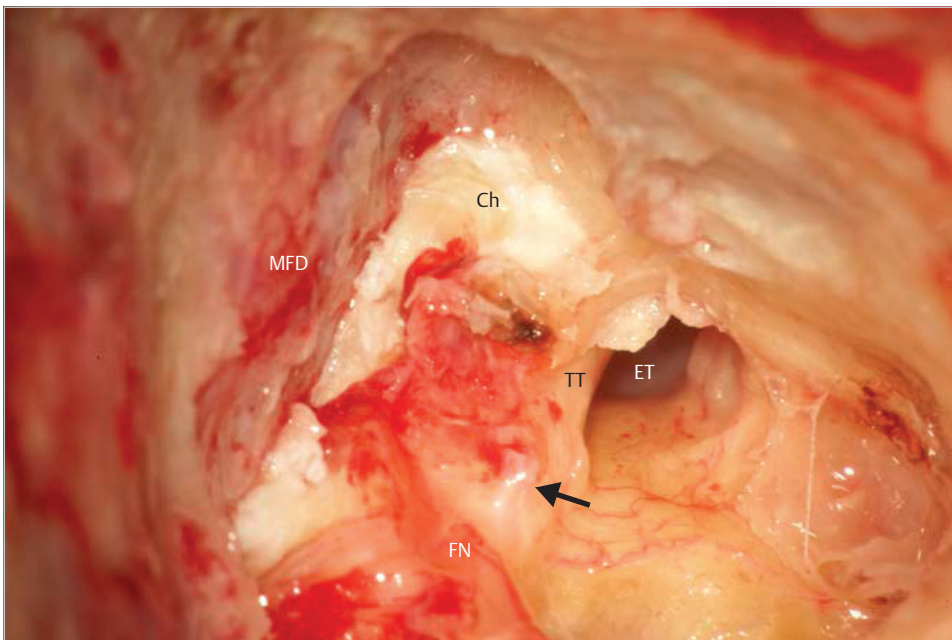


Fig. 14.104 The most anterior part of the cholesteatoma is shown. The arrow shows the cochleariform process which serves for very reliable landmark of the tympanic segment of the facial nerve coursing superomedially to it. The tendon of the tensor tympani muscle turns laterally at this process to reach the superior end of the handle of the malleus. Ch, cholesteatoma; ET, eustachian tube; FN, facial nerve; MFD, middle fossa dura; TT, tensor tympani (semicanal).

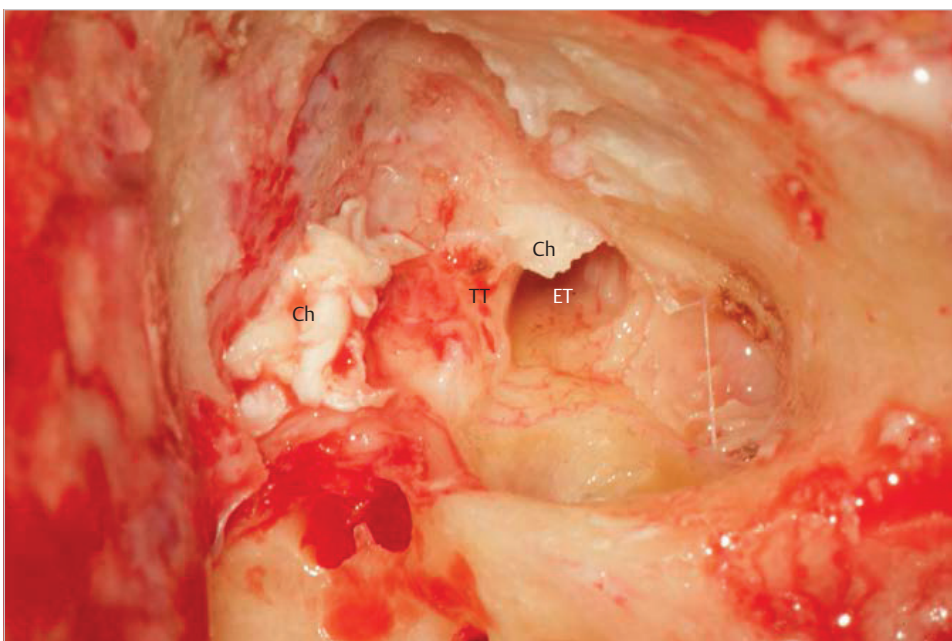


Fig. 14.105 Dissection of the cholesteatoma from the supratubal recess is advanced medially and anteriorly. The cholesteatoma passes over the tensor tympani muscle to reach the eustachian tube and also infiltrates the medial wall of the attic. Ch, cholesteatoma; ET, eustachian tube; TT, tensor tympani (semicanal).



Fig. 14.106 The cochleariform process is removed together with the tensor tympani muscle taking care not to damage the facial nerve. ET, eustachian tube; FN, facial nerve.

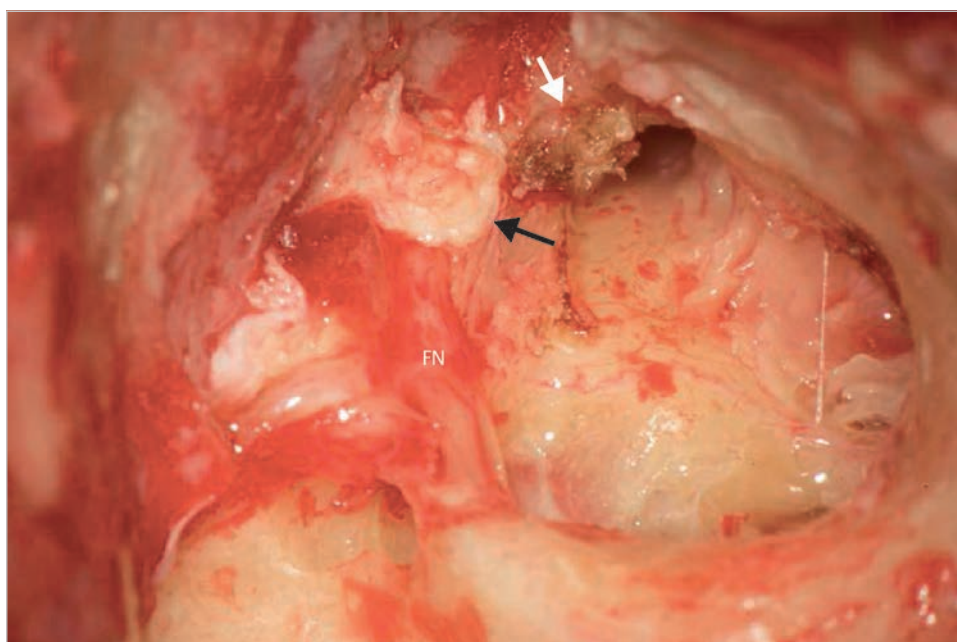


Fig. 14.107 The tensor tympani muscle is severed and bipolar coagulated (*white arrow*). The procedure exposed the inferior aspect of the cholesteatoma (*black arrow*) located laterally to the facial nerve. FN, facial nerve.

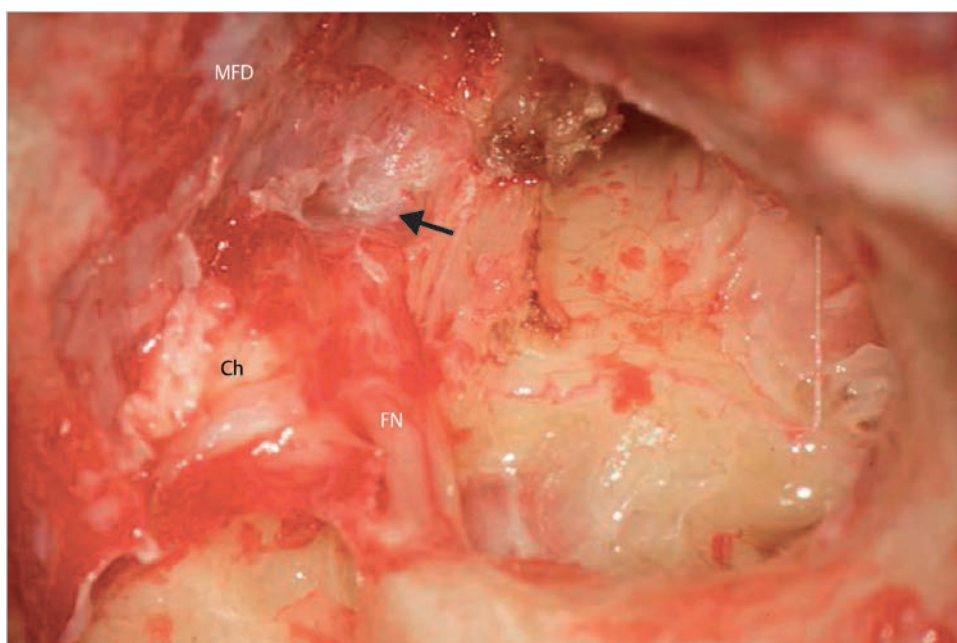


Fig. 14.108 Remnant of the very thin matrix covering the facial nerve and the middle fossa dura is shown (*arrow*). Note the thin matrix. Insufficient exposure of such area may cause residual cholesteatoma afterward. Ch, cholesteatoma; MFD, middle fossa dura; FN, facial nerve.

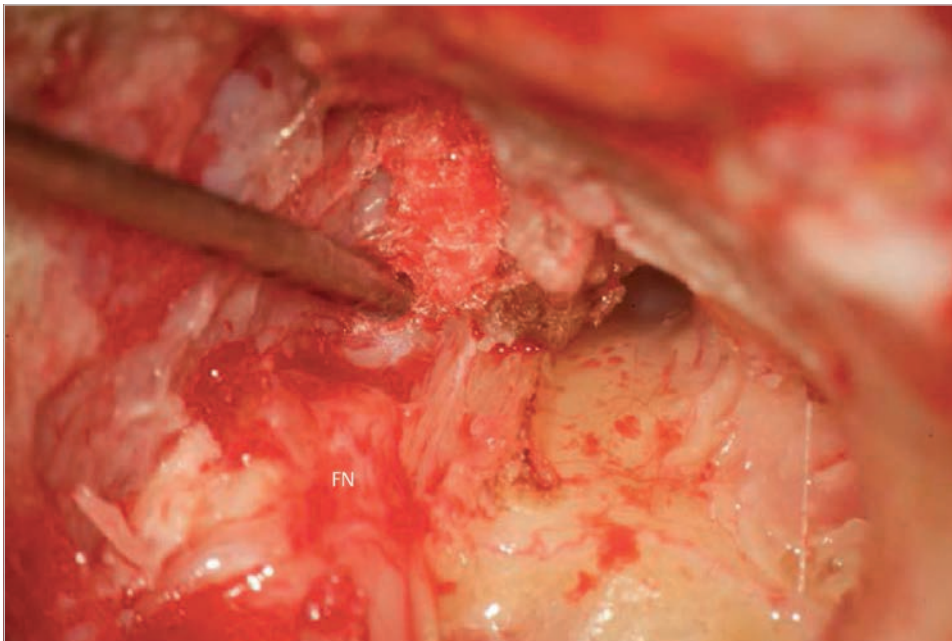


Fig. 14.109 The most anterior part of the cholesteatoma covering the geniculate ganglion of the facial nerve is dissected with cottonoid. FN, facial nerve.

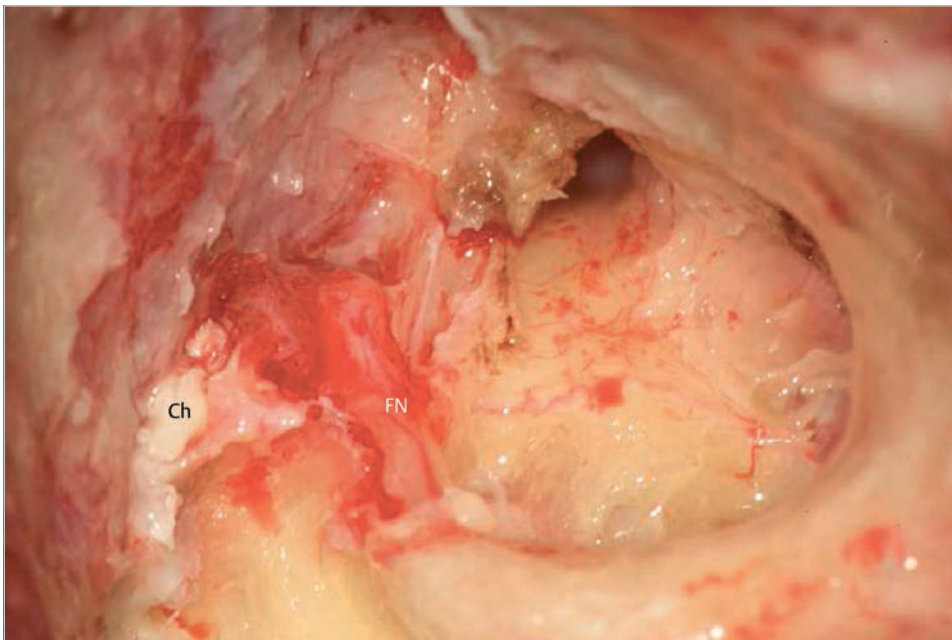


Fig. 14.110 The cholesteatoma matrix is eradicated from the supratubal recess. Ch, cholesteatoma; FN, facial nerve.

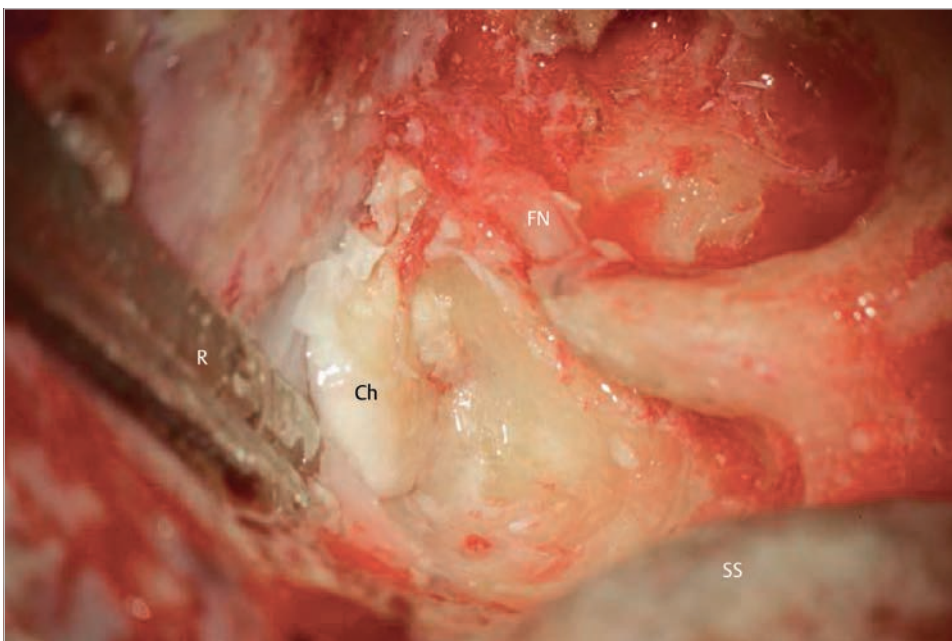


Fig. 14.111 Ampullae of the lateral and the superior semicircular canals are completely removed to gain access to the cholesteatoma infiltrating deeply the medial wall of the attic. A middle fossa retractor is applied to enlarge access to the cholesteatoma. Ch, cholesteatoma; FN, facial nerve; R, middle fossa retractor; SS, sigmoid sinus.

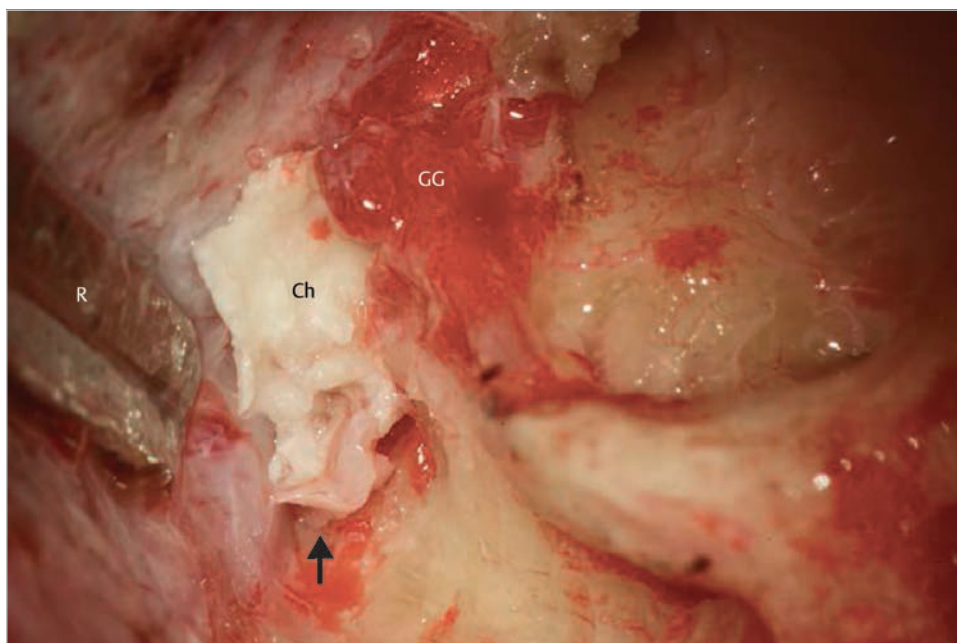


Fig. 14.112 Further drilling of the bone exposed the medial end of the cholesteatoma (*arrow*). Granulation tissue covers the superior aspect of the geniculate ganglion. Ch, cholesteatoma; GG, geniculate ganglion; R, retractor.

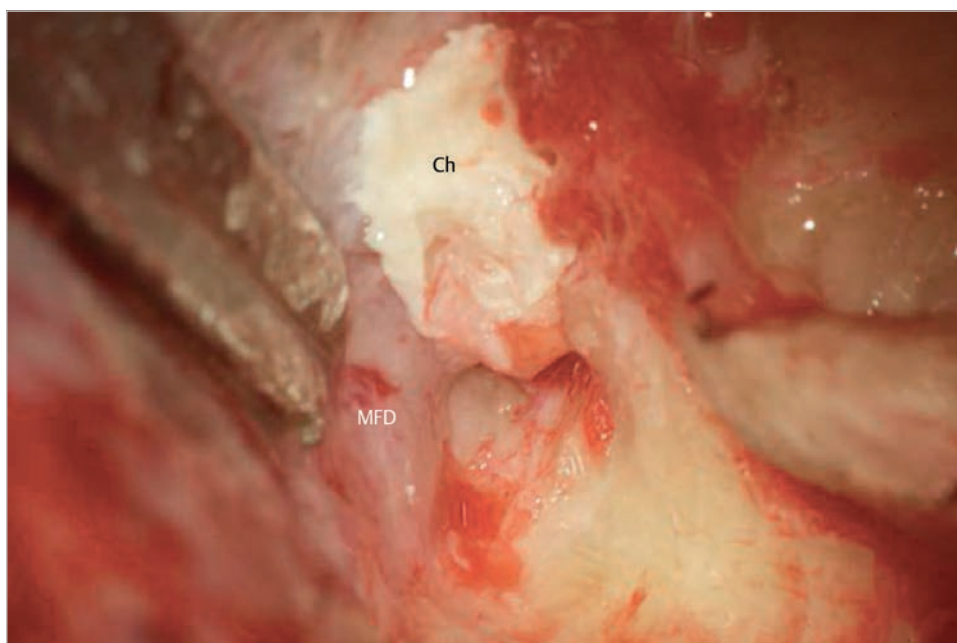


Fig. 14.113 Dissection of the matrix from the middle fossa dura is carried out from posterior to anterior. Ch, cholesteatoma; MFD, middle fossa dura.

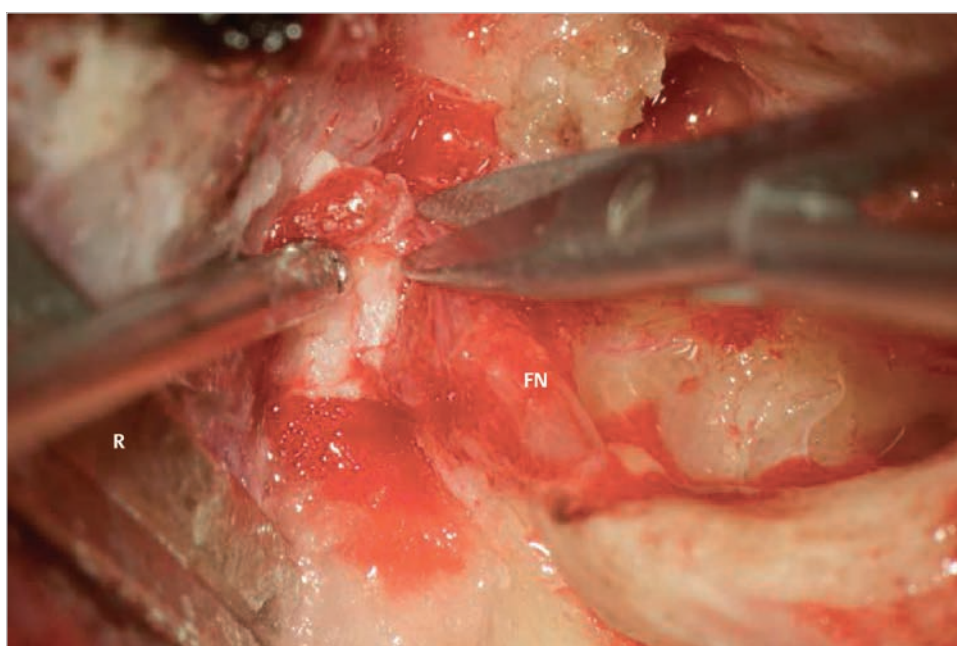


Fig. 14.114 The granulation tissue covering the facial nerve is removed with scissors. FN, facial nerve; R, retractor.

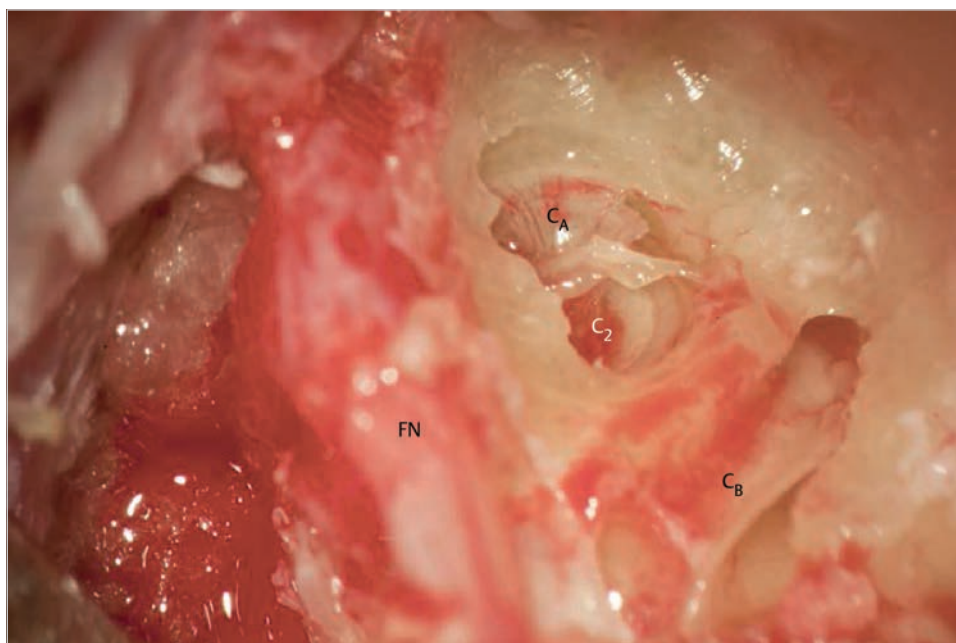


Fig. 14.115 To obtain better access to the area behind the facial nerve, the cochlea needs to be removed. C_A , apical turn of cochlea; C_B , basal turn of cochlea; C_2 , second turn of cochlea; FN, facial nerve.

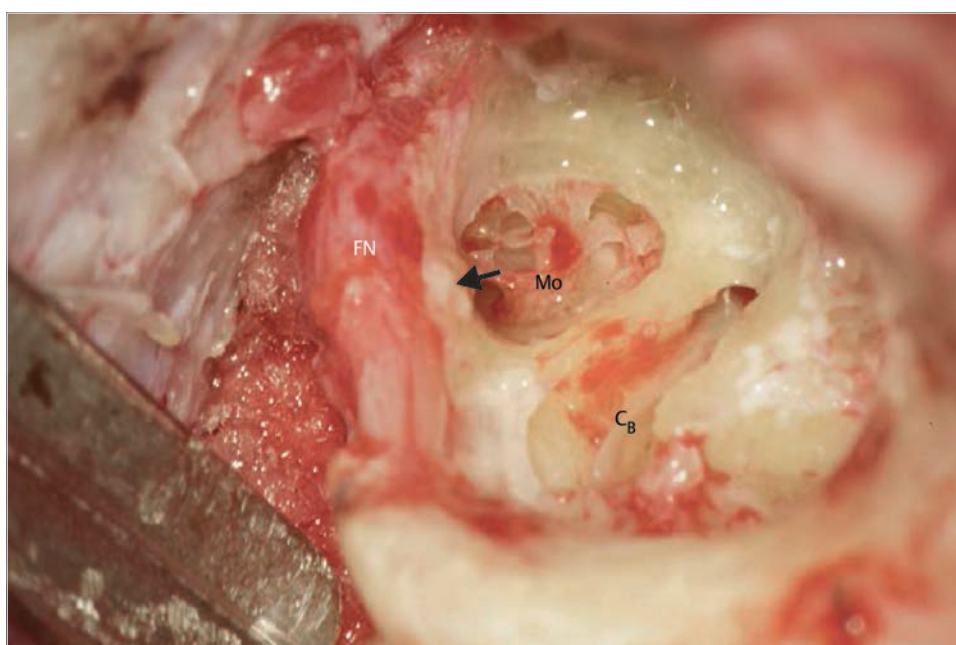


Fig. 14.116 Removal of the apical turn is advanced superiorly and anteriorly to open the area under the facial nerve from inferior. The inferior pole of the cholesteatoma under the facial nerve is identified (arrow). Since view to the inferior aspect of the labyrinthine segment is restricted by the tympanic segment, aggressive drilling under the facial nerve before identifying the labyrinthine segment from the attic is prohibited. C_B , basal turn of cochlea; FN, facial nerve; Mo, modiolus.

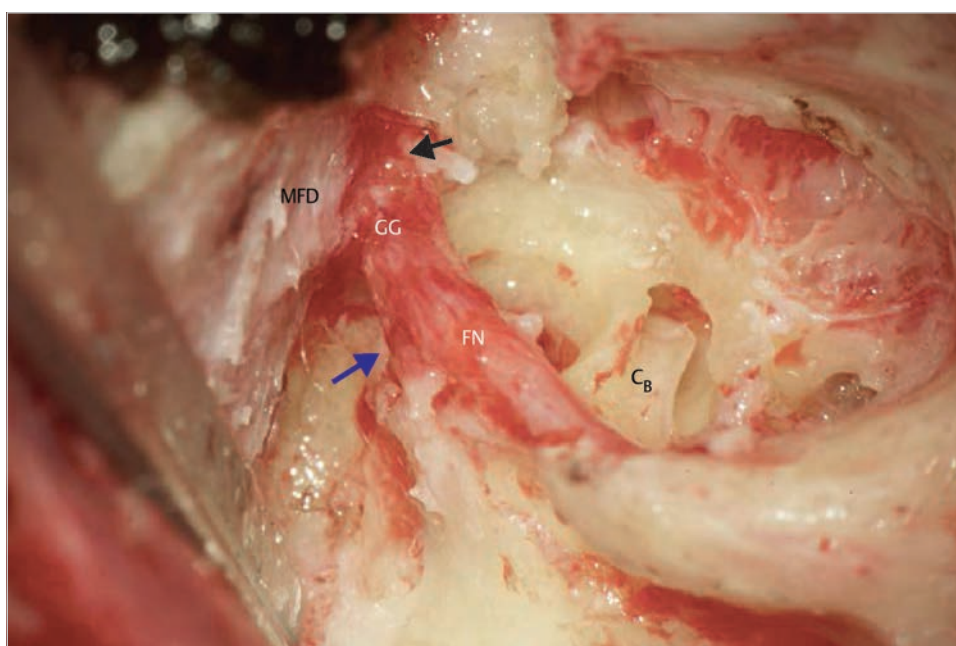


Fig. 14.117 The labyrinthine segment of the nerve (blue arrow) is identified and followed medially. The great superficial petrosal nerve (black arrow) branches from the geniculate ganglion and joins to the middle fossa dura. Note that the facial nerve covers the apical turn of the cochlea when viewed from posterior. C_B , basal turn of cochlea; FN, facial nerve; GG, geniculate ganglion; MFD, middle fossa dura.

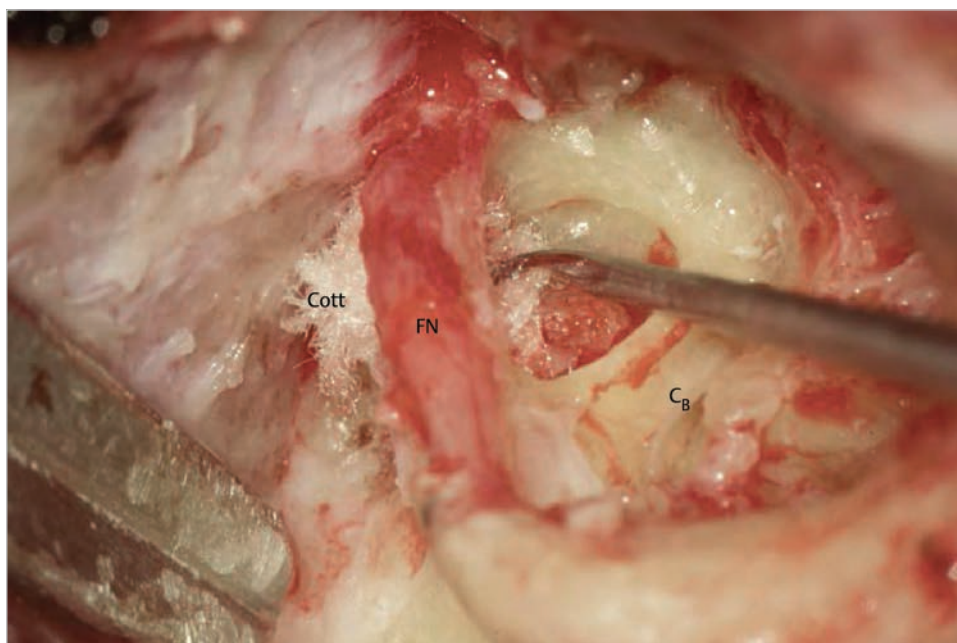


Fig. 14.118 The area under the geniculate ganglion, anteriorly to the labyrinthine segment is opened, and the cholesteatoma is dissected. A possible remnant of cholesteatoma matrix under the facial nerve is cleaned with cottonoid. C_B, basal turn of cochlea; Cott, cottonoid; FN, facial nerve.

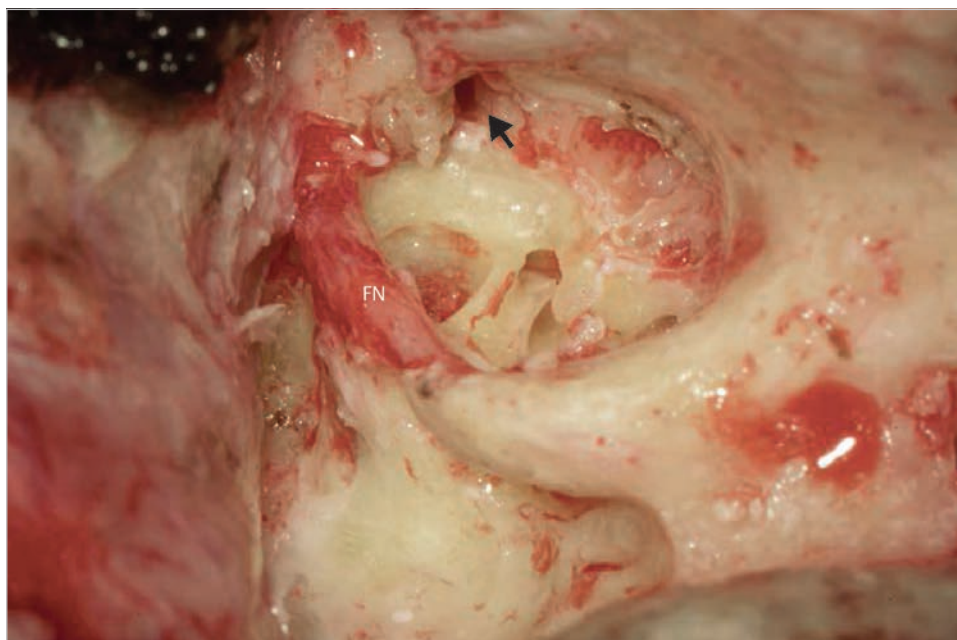


Fig. 14.119 The final shape of the cavity is shown. The eustachian tube (*arrow*) is closed with perichondrium, and the cavity is obliterated with abdominal fat. FN, facial nerve.

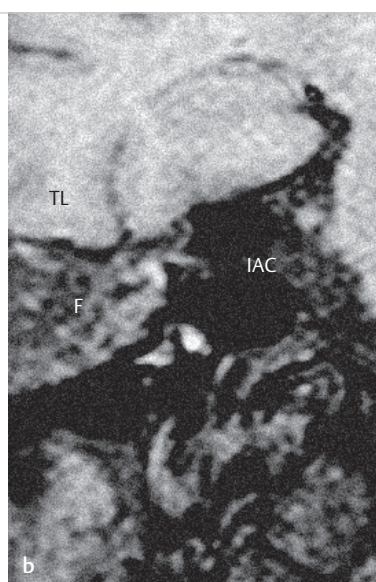
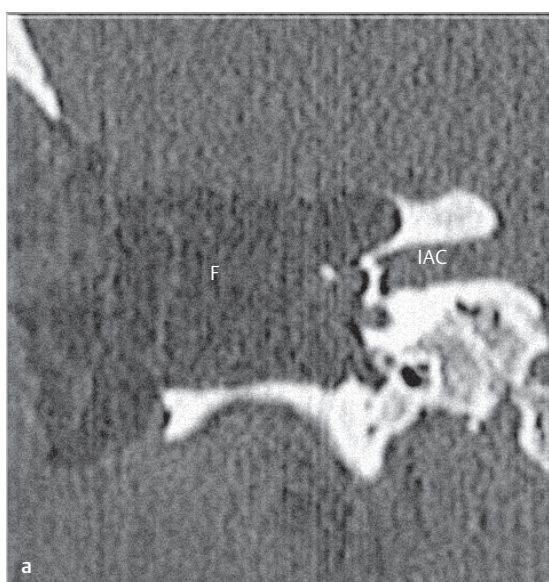


Fig. 14.120 The postoperative coronal CT (a) and MRI (b) show extensive removal of the middle fossa plate to establish wide access to cholesteatoma from superior. Note that the fundus of the internal auditory canal is not insulated. F, abdominal fat; IAC, internal auditory canal; TL, temporal lobe.

Case 14.5 (Left Ear)

See ▶ Fig. 14.121, ▶ Fig. 14.122, ▶ Fig. 14.123, ▶ Fig. 14.124, ▶ Fig. 14.125, ▶ Fig. 14.126, ▶ Fig. 14.127, ▶ Fig. 14.128, ▶ Fig. 14.129, ▶ Fig. 14.130, ▶ Fig. 14.131, ▶ Fig. 14.132, ▶ Fig. 14.133, ▶ Fig. 14.134, ▶ Fig. 14.135, ▶ Fig. 14.136, ▶ Fig. 14.137, ▶ Fig. 14.138.

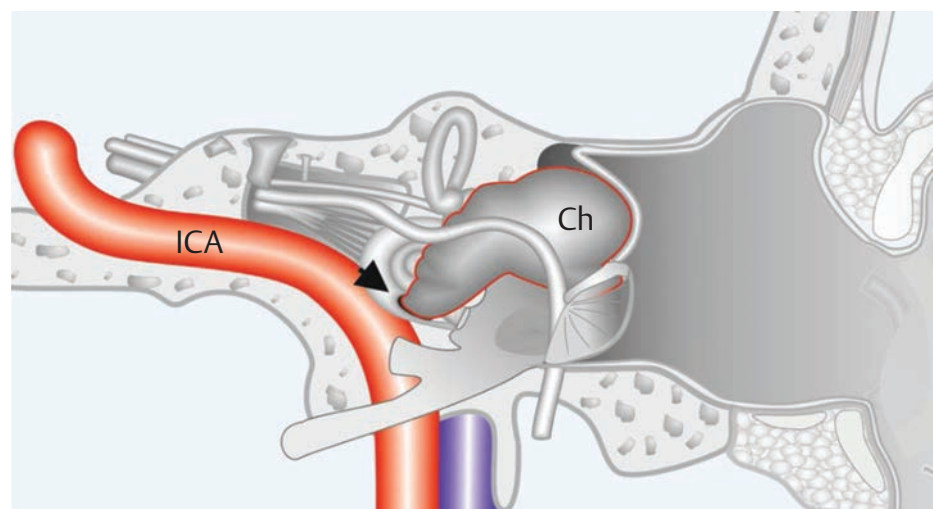


Fig. 14.121 A case of supralabyrinthine petrous bone cholesteatoma arising as a residual in a canal wall down cavity removed with transotic approach. The cholesteatoma erodes both the posterior labyrinth and the cochlea to pass under the tympanic segment of the facial nerve. Ch, cholesteatoma; IAC, internal auditory canal.



Fig. 14.122 The patient underwent canal wall down tympanoplasty in elsewhere. The preoperative otoscopy shows whitish mass located beneath the posterosuperior quadrant of the tympanic membrane corresponding to recurrence of cholesteatoma in the canal wall cavity. Ch, cholesteatoma; TM, tympanic membrane.

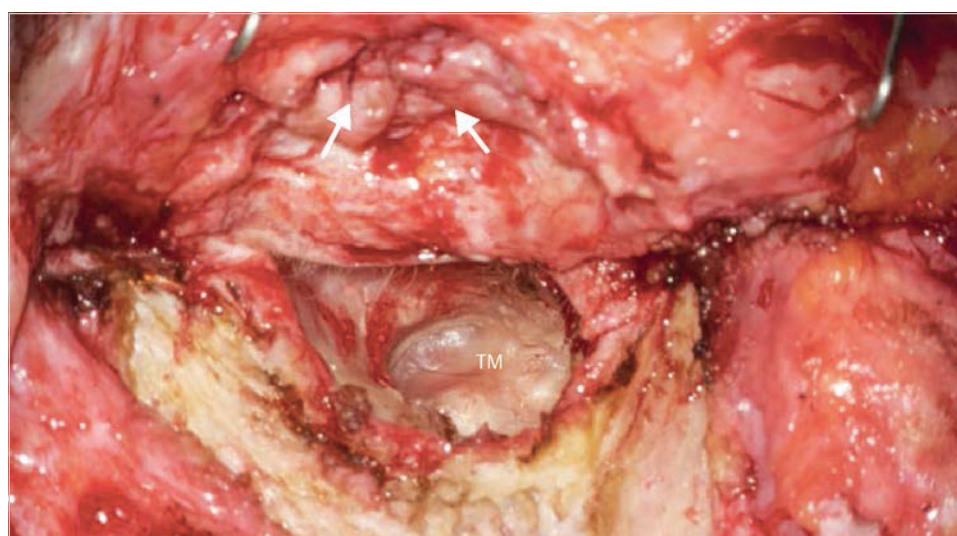


Fig. 14.123 A U-shaped skin incision is conducted, and subcutaneous layer is cut in T shape to enter the cavity and to widely expose cortical bone. After closing the external auditory canal in two layers (arrows), the auricle is maintained with skin hoods. TM, tympanic membrane.

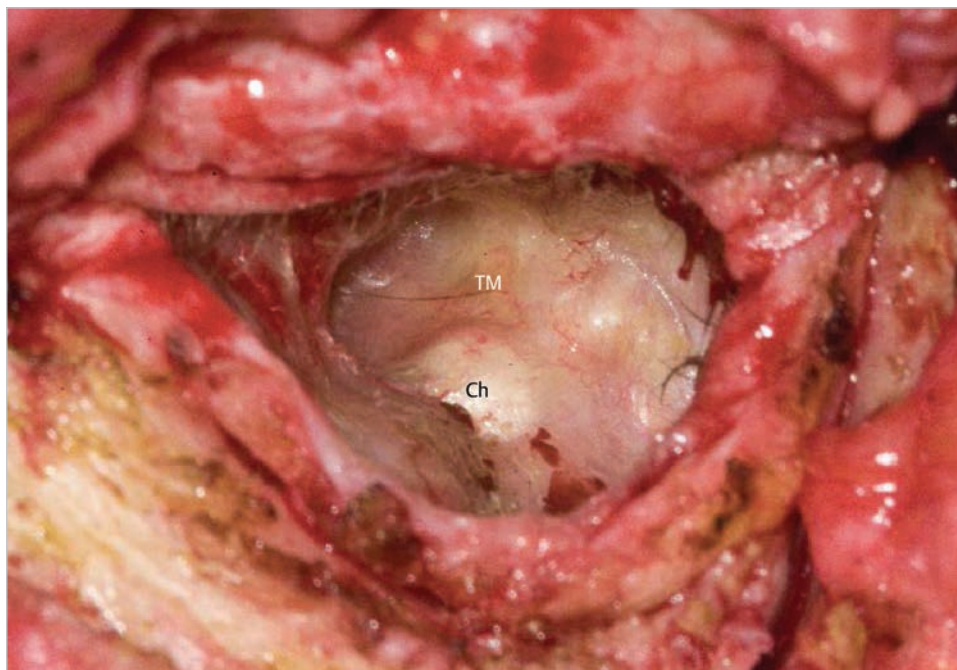


Fig. 14.124 Enlarged view. The cavity is well epithelized. A whitish bulging indicating presence of cholesteatoma is seen in the posterosuperior quadrant of the tympanic membrane. Ch, cholesteatoma; TM, tympanic membrane.

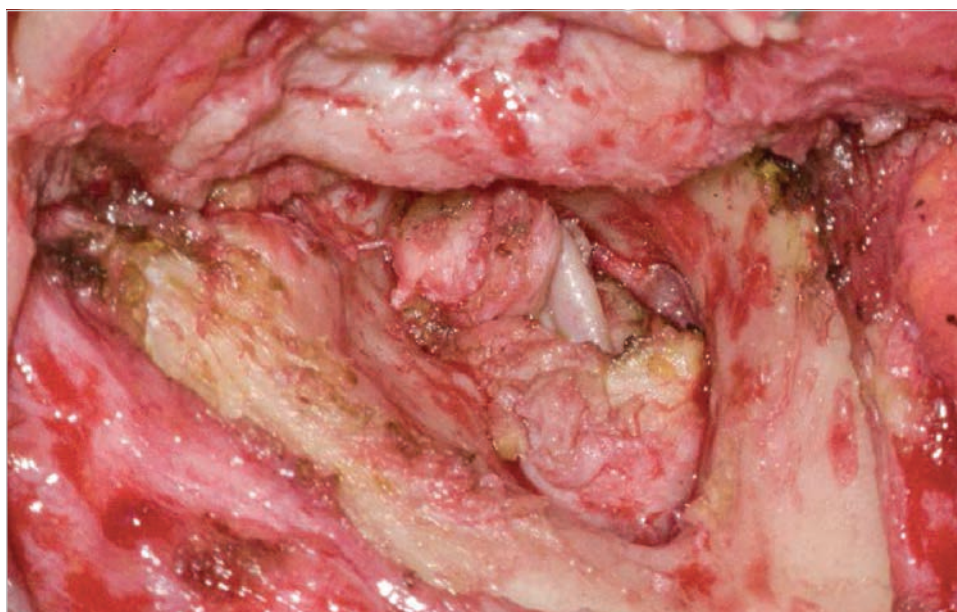


Fig. 14.125 The skin covering the cavity is detached medially, and sharp bony edges limiting access to the cavity are removed.



Fig. 14.126 The medial wall of the cavity is now under control.

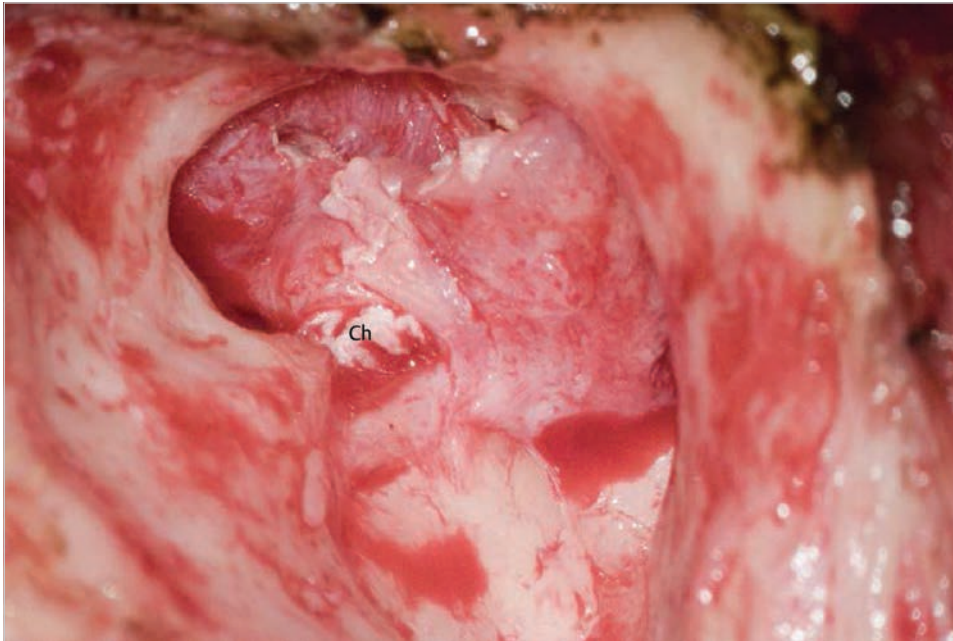


Fig. 14.127 The skin is detached from the medial wall of the mastoid and reflected anteriorly. The tympanic cavity is opened from posterior. The cholesteatoma under the posterosuperior quadrant is started to be seen. Ch, cholesteatoma.

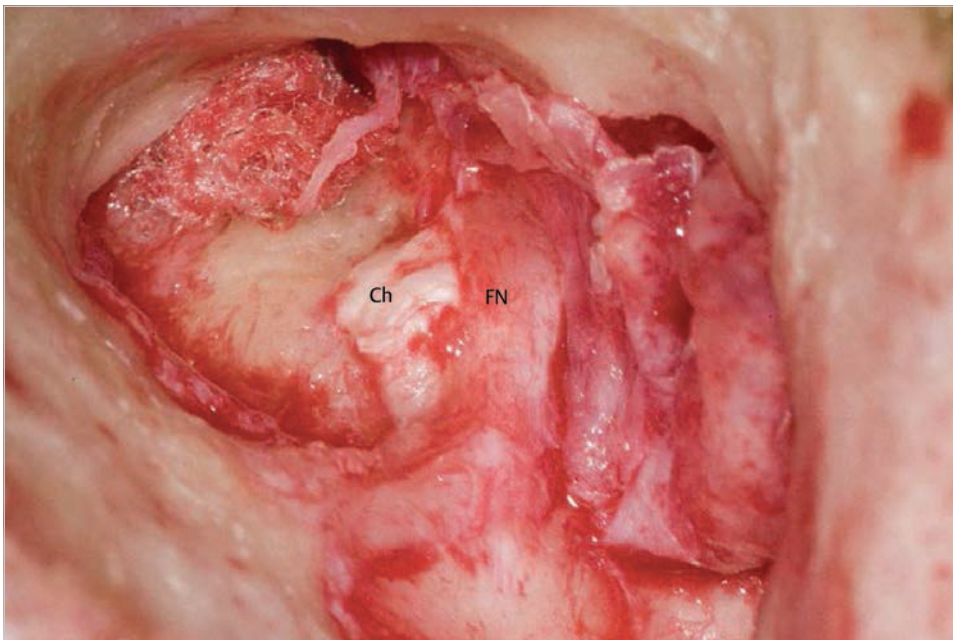


Fig. 14.128 The tympanic membrane is detached from the bony annulus and reflected superiorly to open the tympanic cavity fully. The cholesteatoma occupies the area of the stapes, just under the exposed facial nerve. Ch, cholesteatoma; FN, facial nerve.

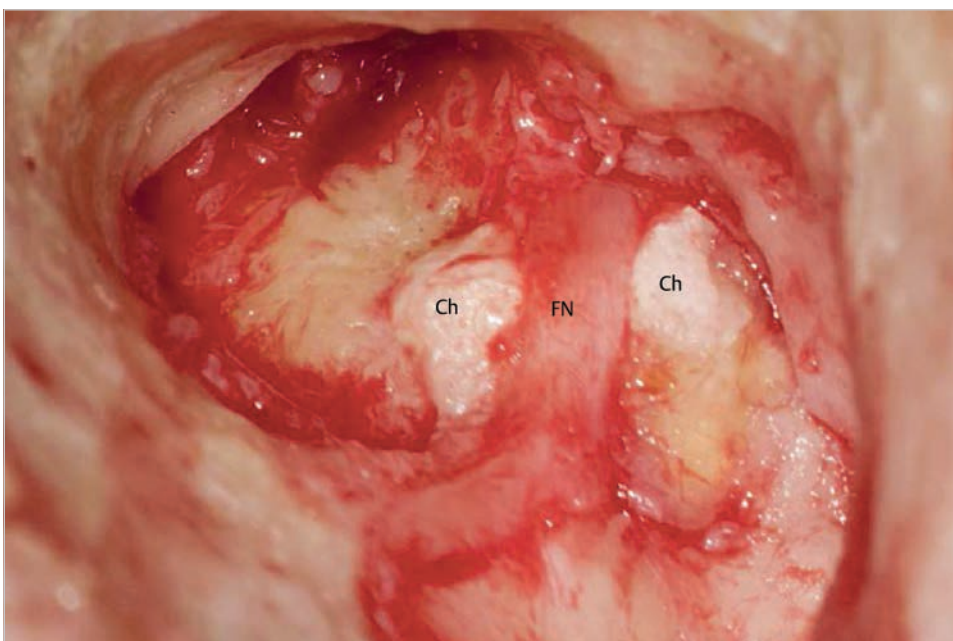


Fig. 14.129 Complete removal of the skin from the cavity revealed cholesteatoma located mainly under the tympanic segment of the facial nerve. Both the medial wall of the attic and the area of the stapes are infiltrated, and the facial nerve is pushed laterally. Ch, cholesteatoma; FN, facial nerve

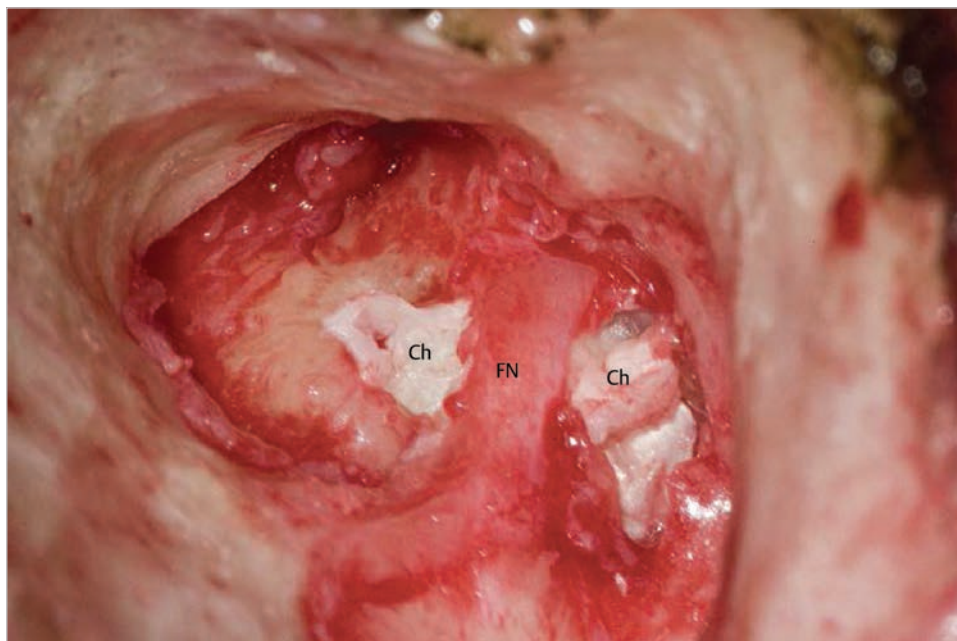


Fig. 14.130 Debulking of the cholesteatoma to facilitate dissection in matrix is ongoing. Ch, cholesteatoma; FN, facial nerve.

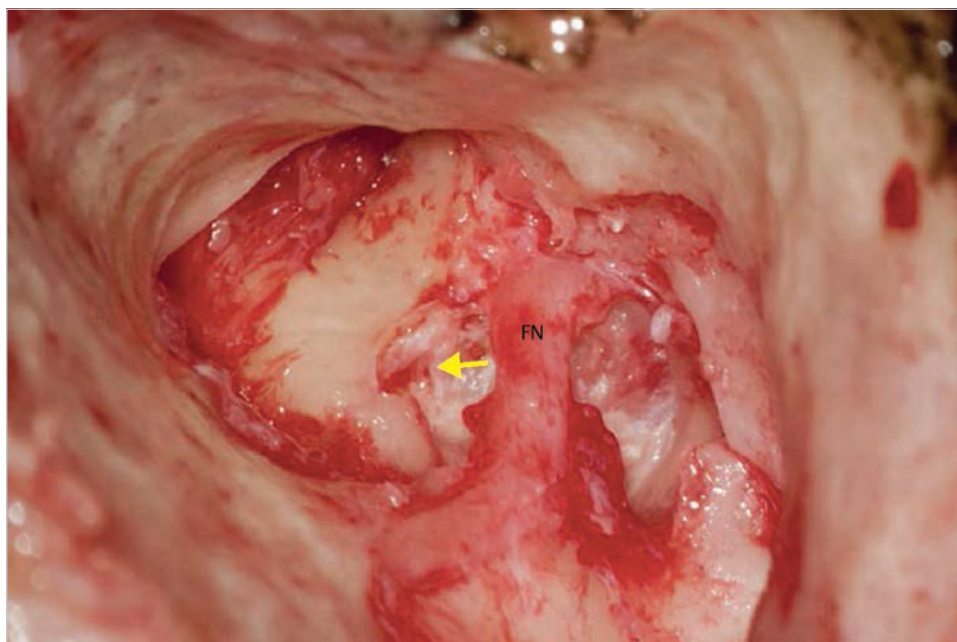


Fig. 14.131 The cholesteatoma completely filling the vestibule to reach the basal turn of the cochlea is shown (*arrow*). FN, facial nerve.

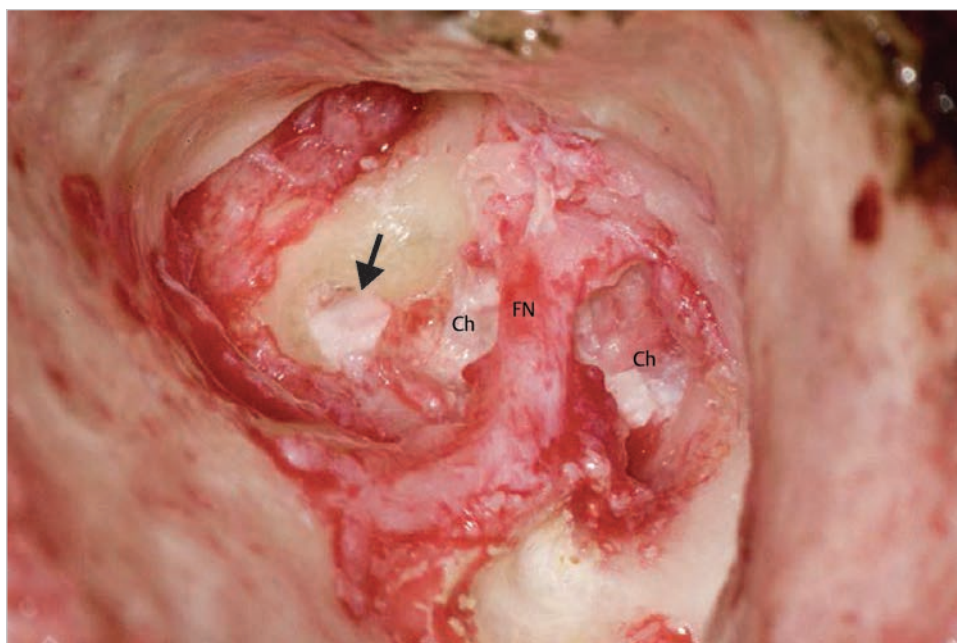


Fig. 14.132 The medial wall of the mesotympanum is drilled to open the cochlea. The cholesteatoma still fills the basal turn (*arrow*). The semicircular canals are started to be removed to open the vestibule. Ch, cholesteatoma; FN, facial nerve.

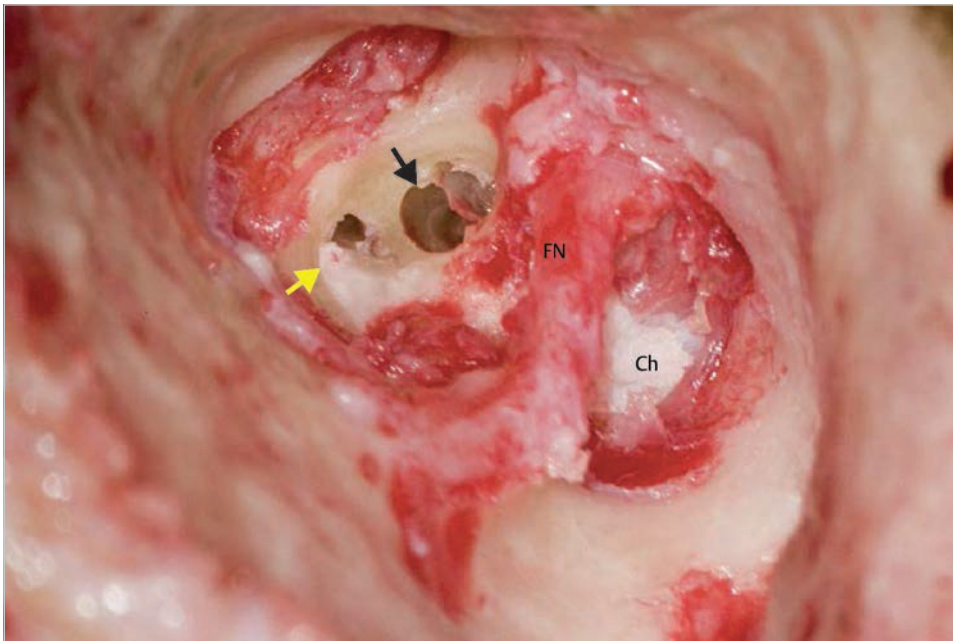


Fig. 14.133 The beginning of the basal turn is occupied by the cholesteatoma. Note that the anterior end of cholesteatoma invaginates only the scala vestibuli (yellow arrow), and the second turn is free of cholesteatoma (black arrow). Ch, cholesteatoma; FN, facial nerve.

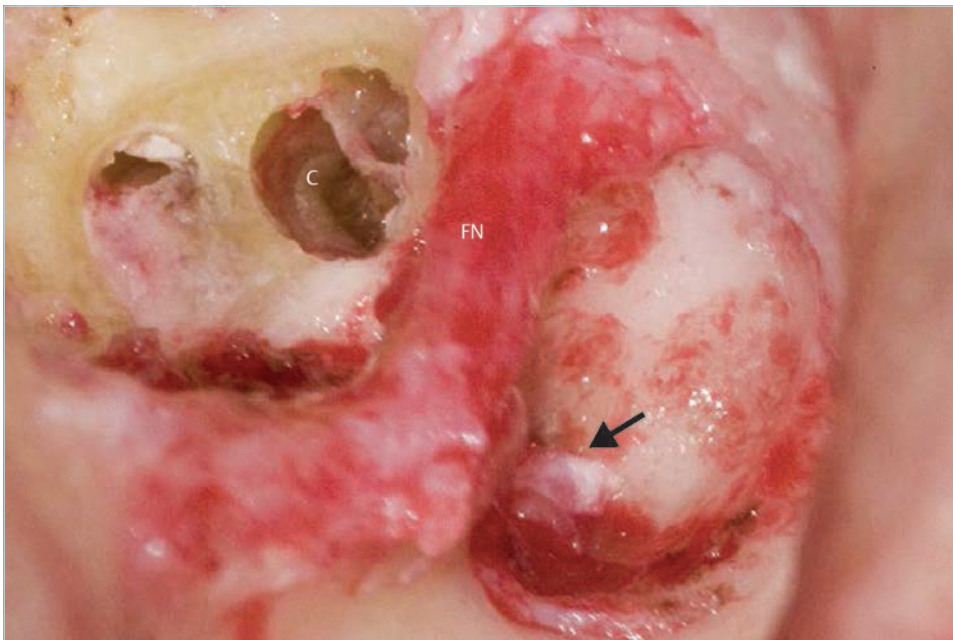


Fig. 14.134 The cochlea is further drilled to remove the cholesteatoma in the basal turn. Cholesteatoma still remains in the vestibule (arrow). C, cochlea; FN, facial nerve.

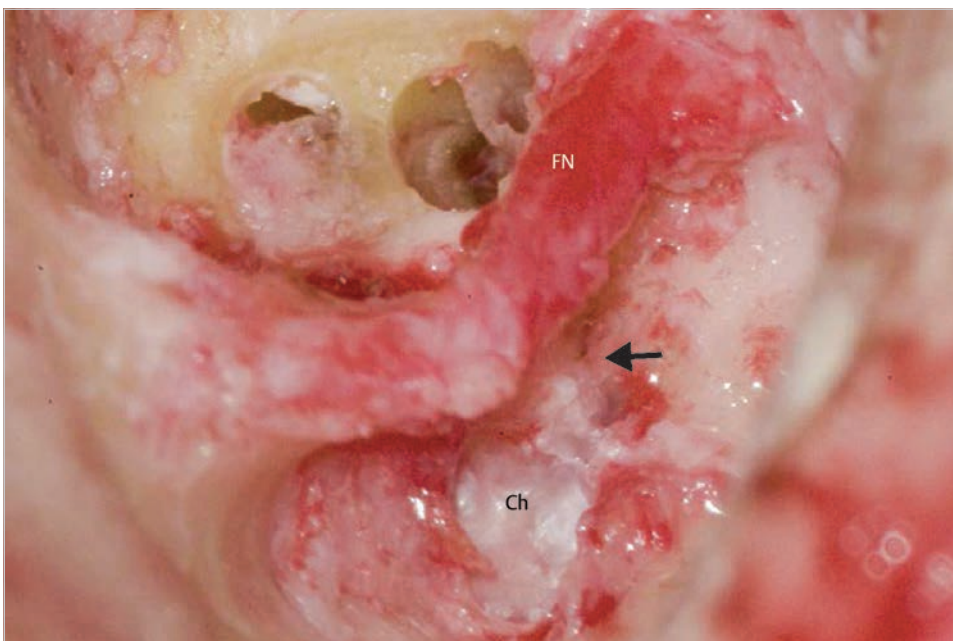


Fig. 14.135 Drilling under the facial nerve is advanced inferiorly to expose the most medial part of cholesteatoma in the vestibule reaching the fundus of the internal auditory canal (arrow). Ch, cholesteatoma; FN, facial nerve.

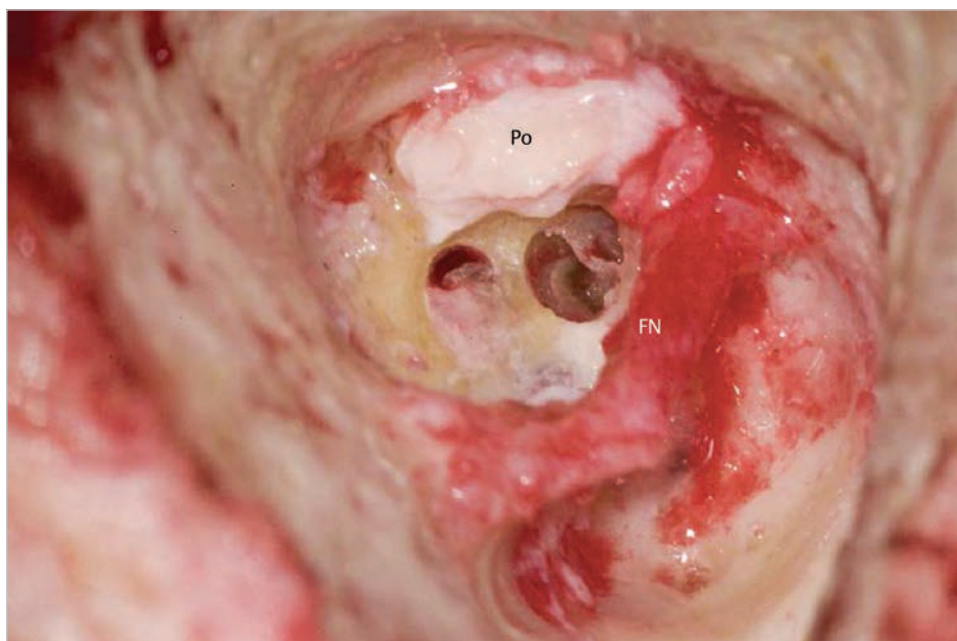


Fig. 14.136 The cells posterior to the internal auditory canal is drilled and cholesteatoma is eradicated from the temporal bone. The eustachian tube is obliterated with periosteum. FN, facial nerve; Po, periosteum.

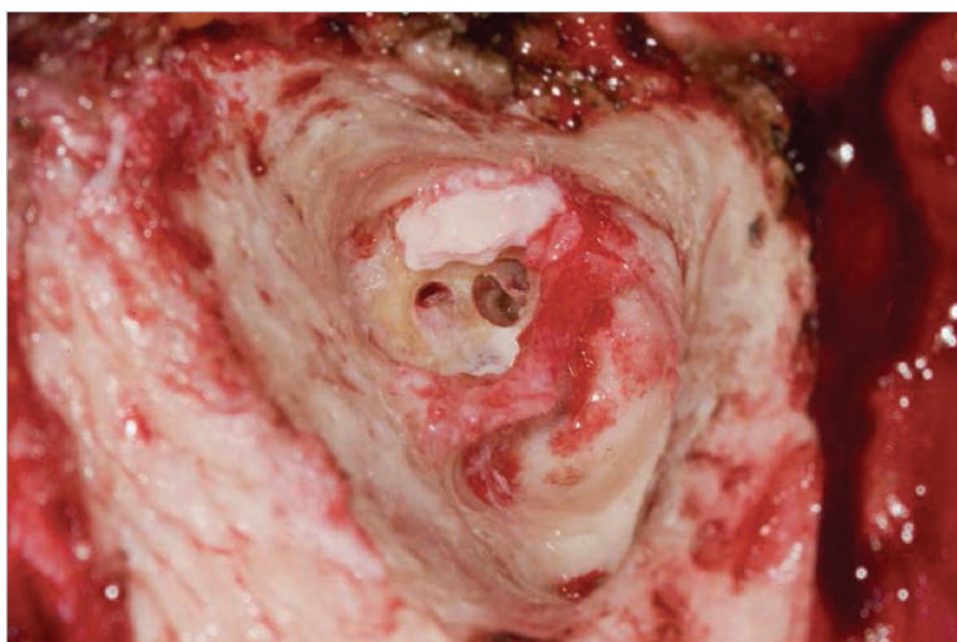


Fig. 14.137 The final shape of the cavity is shown. Since the cholesteatoma is limited to the labyrinth, the middle fossa dura and posterior fossa dura are not exposed.

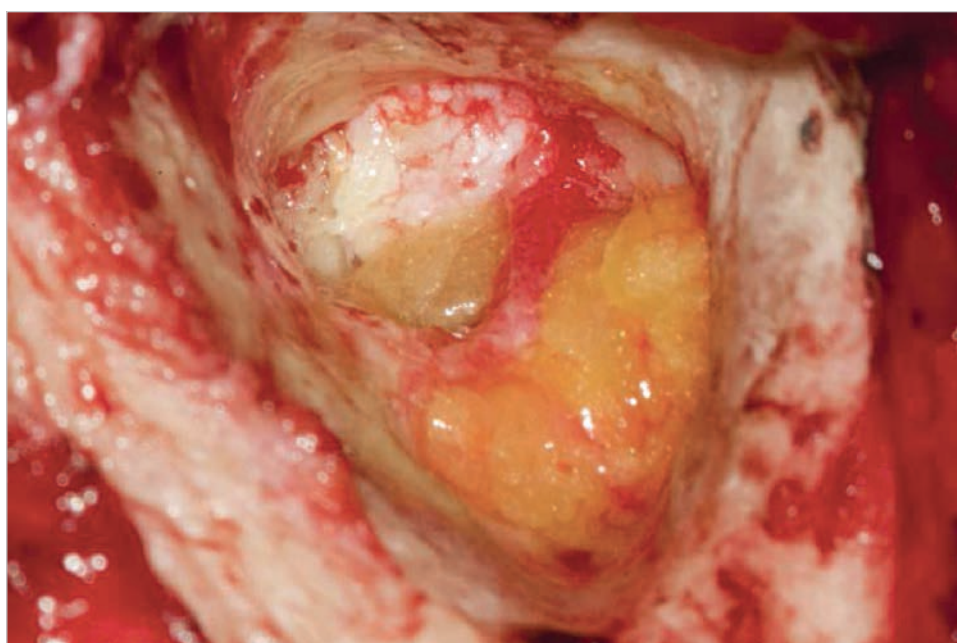


Fig. 14.138 The cavity is obliterated with abdominal fat.

Case 14.6 (Right Ear)

See ▶ Fig. 14.139, ▶ Fig. 14.140, ▶ Fig. 14.141, ▶ Fig. 14.142, ▶ Fig. 14.143, ▶ Fig. 14.144, ▶ Fig. 14.145, ▶ Fig. 14.146, ▶ Fig. 14.147, ▶ Fig. 14.148, ▶ Fig. 14.149, ▶ Fig. 14.150, ▶ Fig. 14.151, ▶ Fig. 14.152,

▶ Fig. 14.153, ▶ Fig. 14.154, ▶ Fig. 14.155, ▶ Fig. 14.156, ▶ Fig. 14.157, ▶ Fig. 14.158, ▶ Fig. 14.159, ▶ Fig. 14.160, ▶ Fig. 14.161, ▶ Fig. 14.162, ▶ Fig. 14.163, ▶ Fig. 14.164, ▶ Fig. 14.165, ▶ Fig. 14.166, ▶ Fig. 14.167, ▶ Fig. 14.168, ▶ Fig. 14.169, ▶ Fig. 14.170, ▶ Fig. 14.171, ▶ Fig. 14.172, ▶ Fig. 14.173.

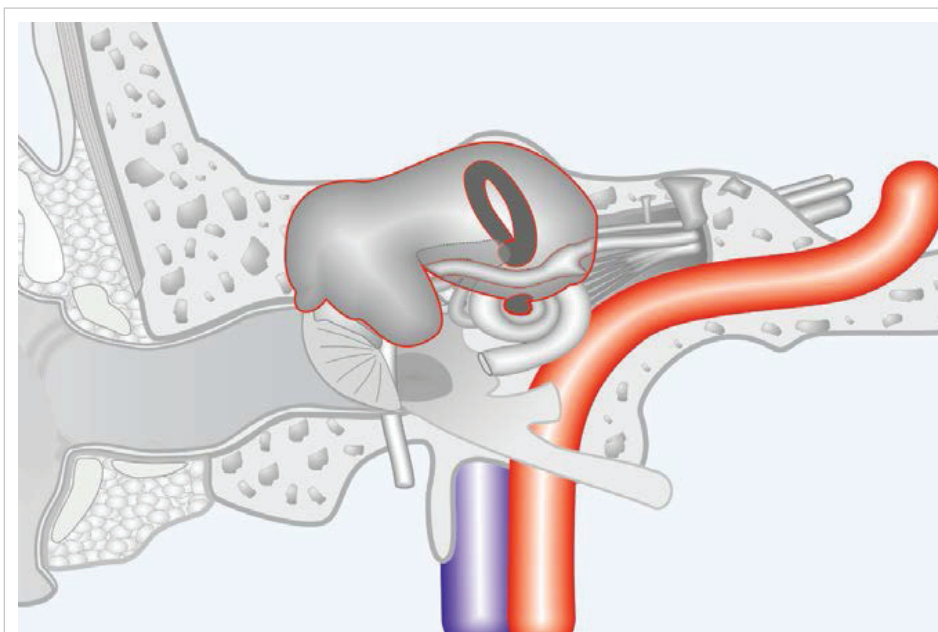


Fig. 14.139 A case of acquired supralabyrinthine petrous bone cholesteatoma with extensive erosion in the posterior labyrinth and a small erosion in the cochlea removed with transotic approach.

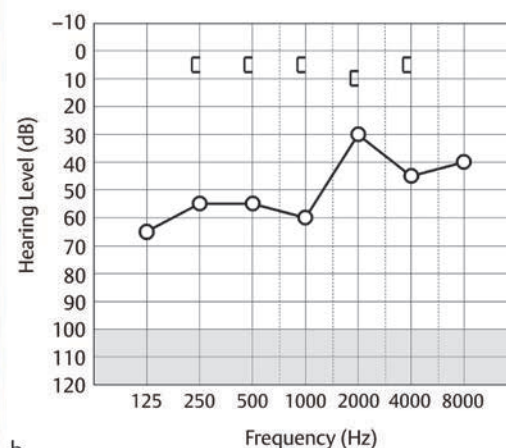


Fig. 14.140 The 57-year-old patient had a history of right-sided hearing loss for years without any sequel until he suffered from sustained complete facial nerve palsy 2 months before. The otoscopy shows small but deep dimple in the pars flaccida, but no sign of the presence of active cholesteatoma is seen. Preoperative audiogram demonstrates moderate conductive hearing loss in the right with good bone conduction. The hearing in the contralateral ear remains normal.

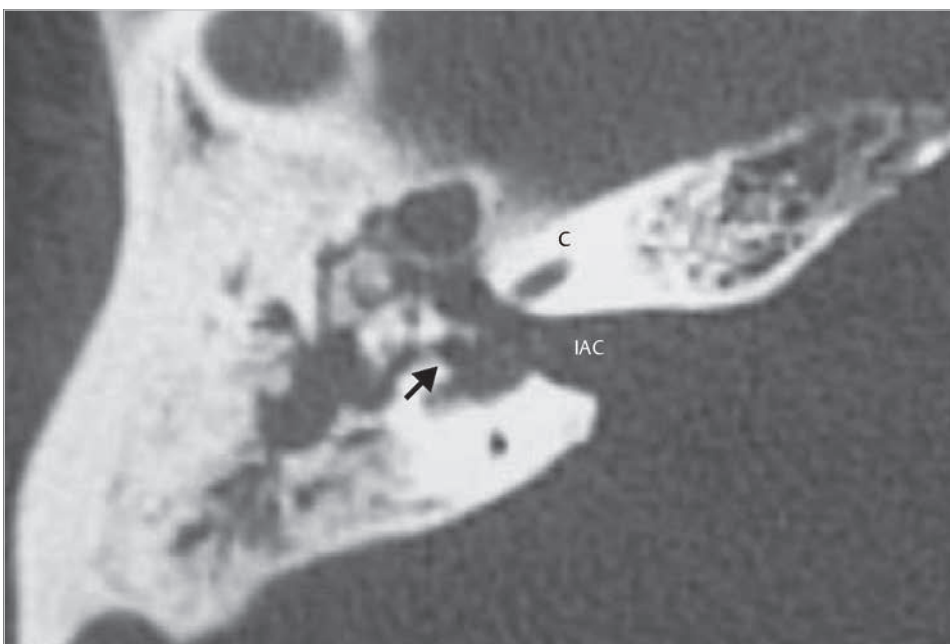


Fig. 14.141 The preoperative axial CT shows extension of the cholesteatoma matrix toward the fundus of the internal auditory canal eroding the labyrinthine segment of the fallopian canal and the bone medially to the ampulla of the superior semicircular canal (arrow). C, cochlea; IAC, internal auditory canal.

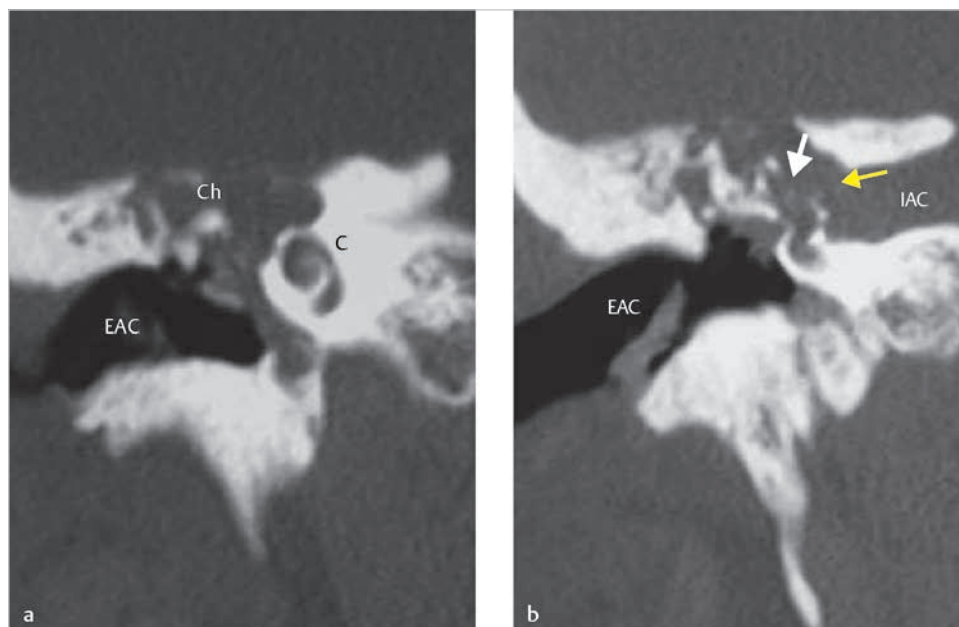


Fig. 14.142 The coronal CT (a) shows presence of cholesteatoma superiorly to the cochlea, involving the area of the geniculate ganglion. More posterior section (b) shows extensive bone erosion at the fundus (yellow arrow) and the vestibule (white arrow). C, cochlea; Ch, cholesteatoma; EAC, external auditory canal; IAC, internal auditory canal.

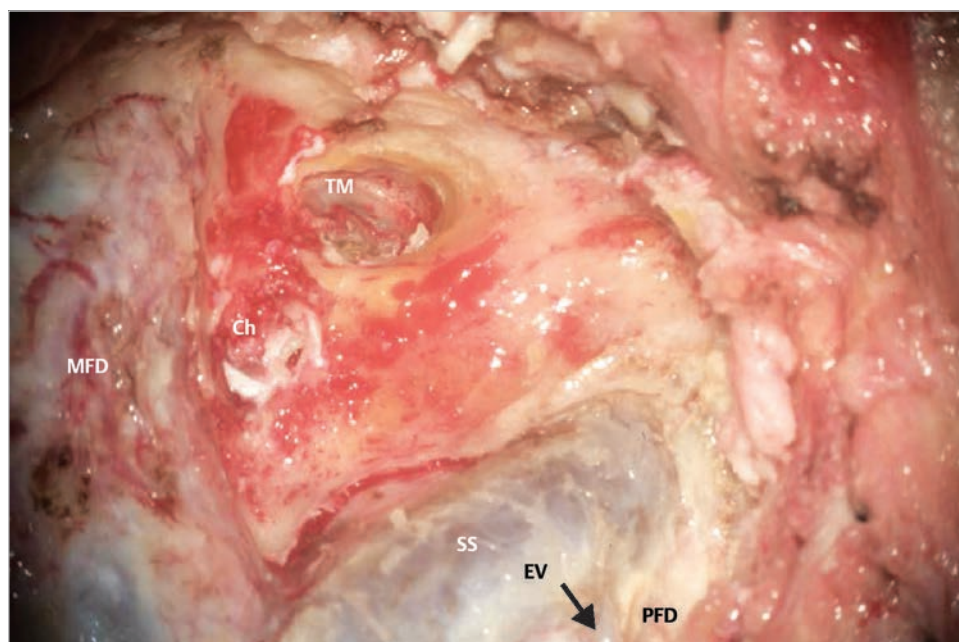


Fig. 14.143 Approach to manage extensive petrous bone cholesteatoma is shown. The middle fossa dura and the sigmoid sinus are widely exposed without leaving any bony coverage. The posterior fossa dura located posteriorly to the sigmoid sinus is also uncovered for sufficient mobilization of the sigmoid sinus. Ch, cholesteatoma; EV, emissary vein; MFD, middle fossa dura; PFD, posterior fossa dura; SS, sigmoid sinus; TM, tympanic membrane.



Fig. 14.144 The posterior wall is partially removed, and the skin in the external auditory canal is removed. The anterior and inferior walls of the external auditory canal are also drilled to improve access to the tympanic cavity. The tympanic membrane is left in place at this moment. The cholesteatoma invaginating from the posterosuperior quadrant of the tympanic membrane (arrow) to fill the attic is seen. Ch, cholesteatoma.

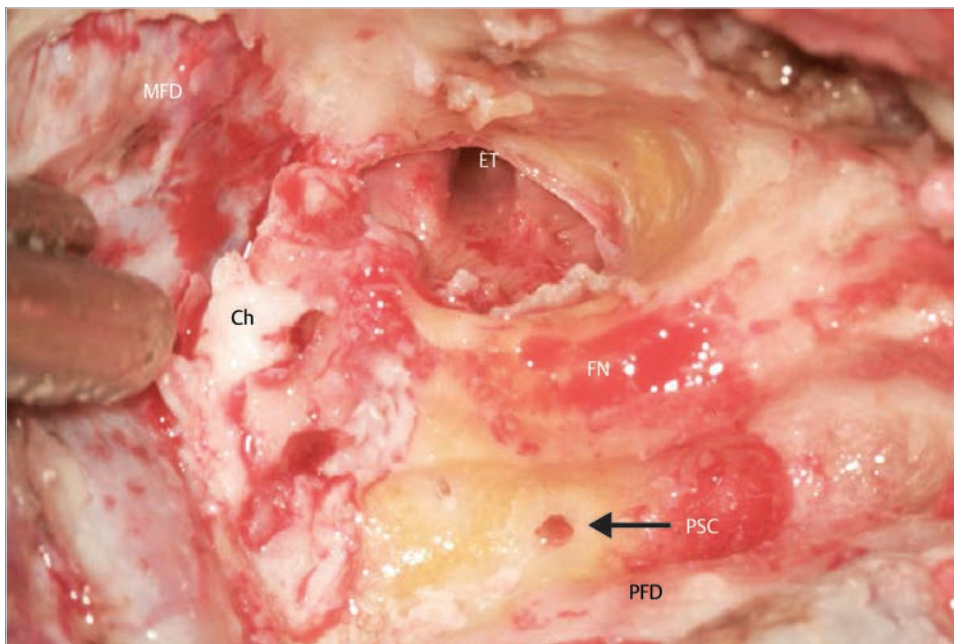


Fig. 14.145 The cholesteatoma advanced posteromedially from the attic to infiltrate the air cells medially to the semicircular canals. The middle fossa dura is pushed superiorly with the suction irrigator to evaluate extension of cholesteatoma. Ch, cholesteatoma; ET, eustachian tube; FN, facial nerve; MFD, middle fossa dura; PFD, posterior fossa dura; PSC, posterior semicircular canal.

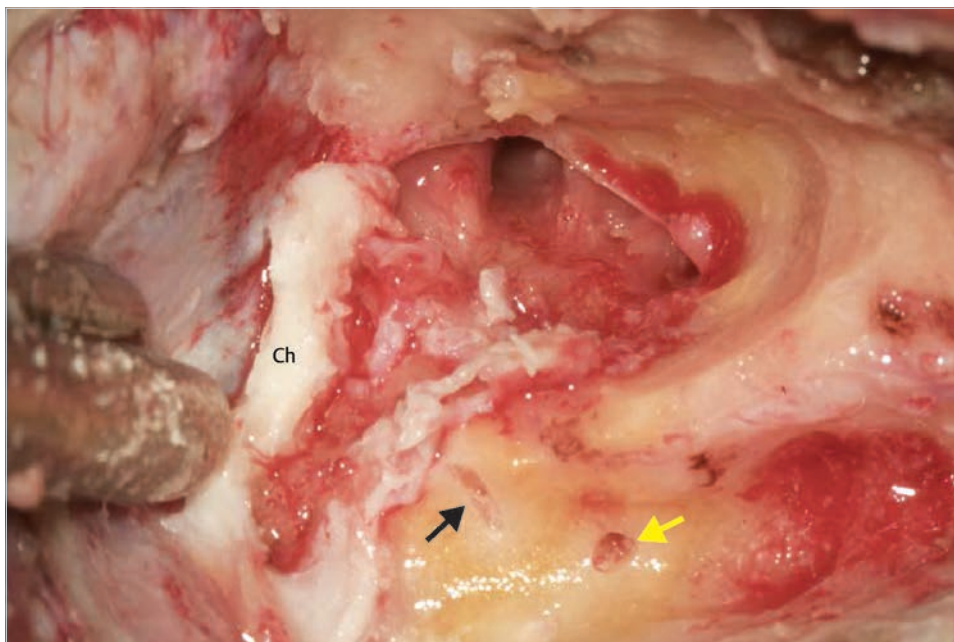


Fig. 14.146 Labyrinthectomy is started to remove cholesteatoma located medially to the labyrinth. The cholesteatoma mainly eroded anterosuperior part of the labyrinth. The lateral semicircular canal is opened (black arrow), and the posterior semicircular canal (yellow arrow) is drilled. Ch, cholesteatoma.

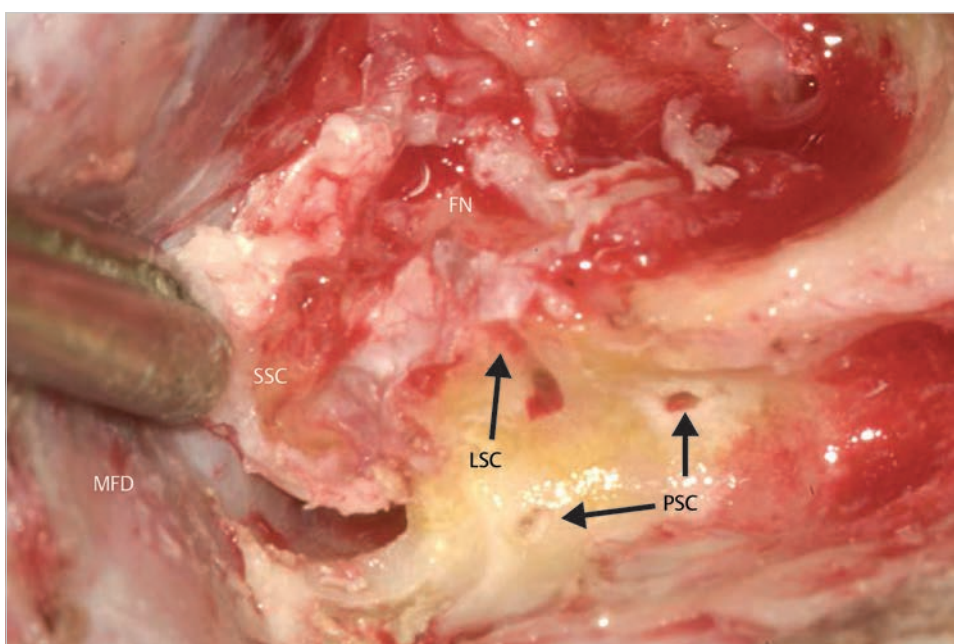


Fig. 14.147 Removal of the posterior labyrinth is further carried out. The anterior half of the lateral semicircular canal is infiltrated by the cholesteatoma. FN, facial nerve; LSC, lateral semicircular canal; MFD, middle fossa dura; PSC, posterior semicircular canal; SSC, superior semicircular canal.

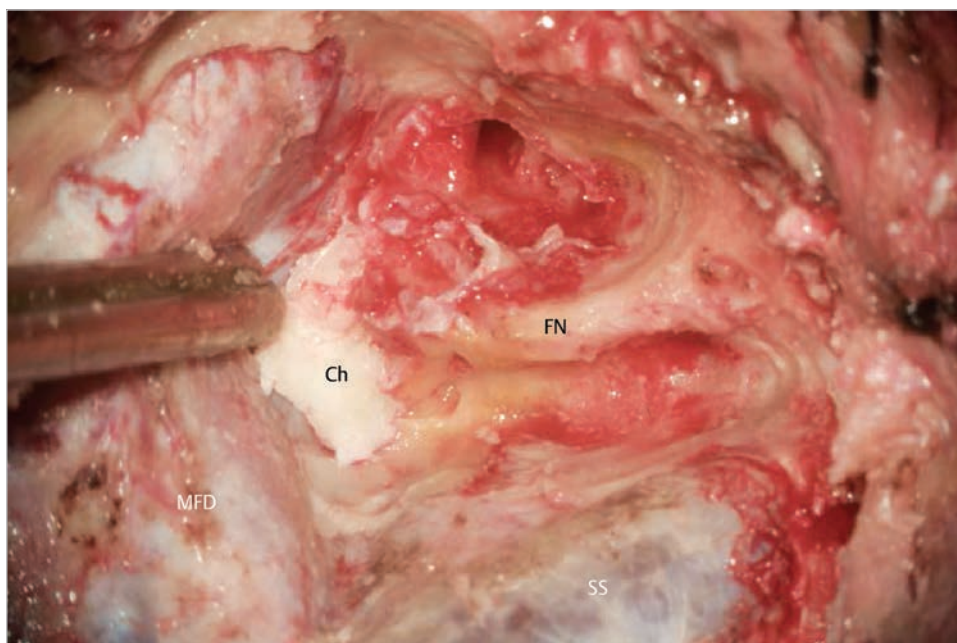


Fig. 14.148 The lateral and the posterior semicircular canals are removed. The cholesteatoma erodes the medial wall of the attic to go deeply toward the internal auditory canal. Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa plate; SS, sigmoid sinus.

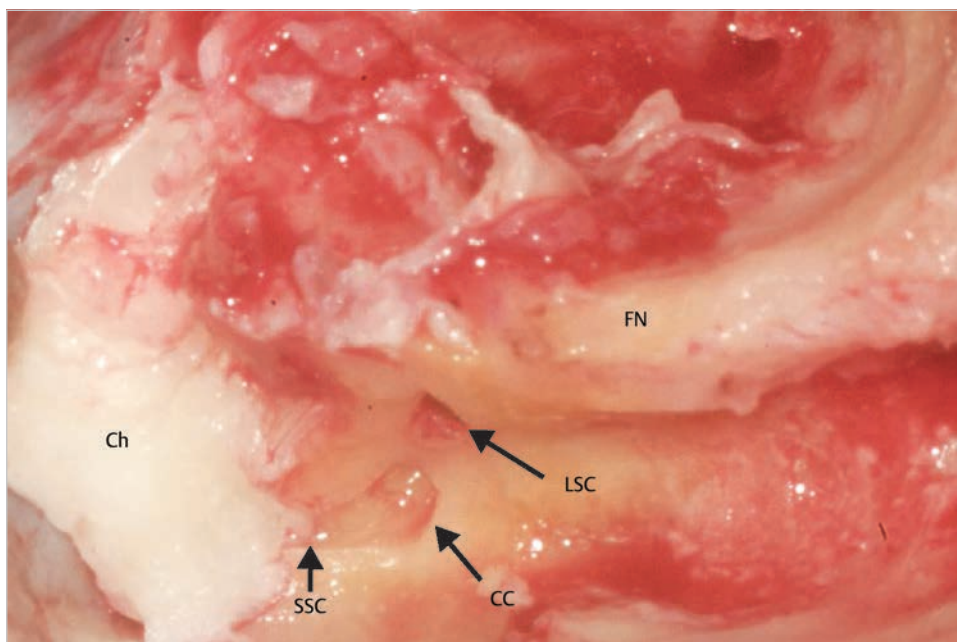


Fig. 14.149 Enlarged view. Removal of the posterior semicircular canal visualized the common crus. Note that the superior semicircular canal is infiltrated by the cholesteatoma. The posterior end of the lateral semicircular canal is seen. CC, common crus; Ch, cholesteatoma; FN, facial nerve; LSC, lateral semicircular canal; SSC, superior semicircular canal.

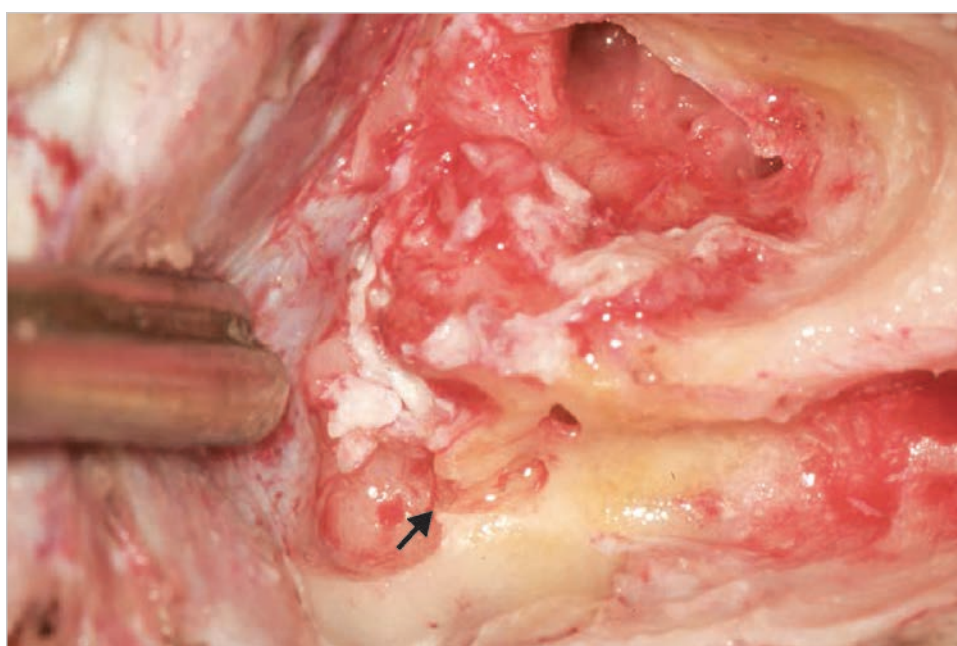


Fig. 14.150 The superior semicircular canal is interrupted by the cholesteatoma (arrow).

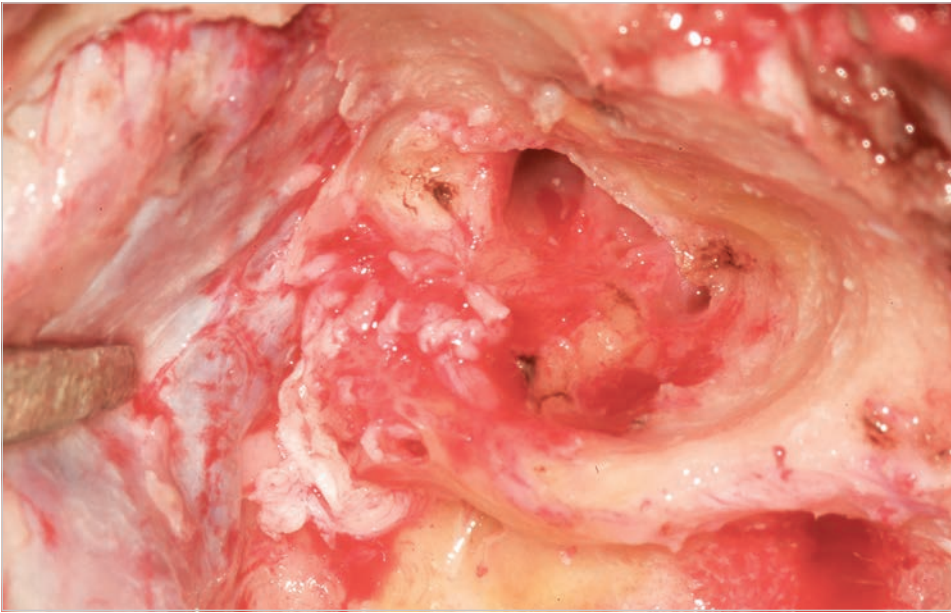


Fig. 14.151 The geniculate ganglion is completely encased in the cholesteatoma.

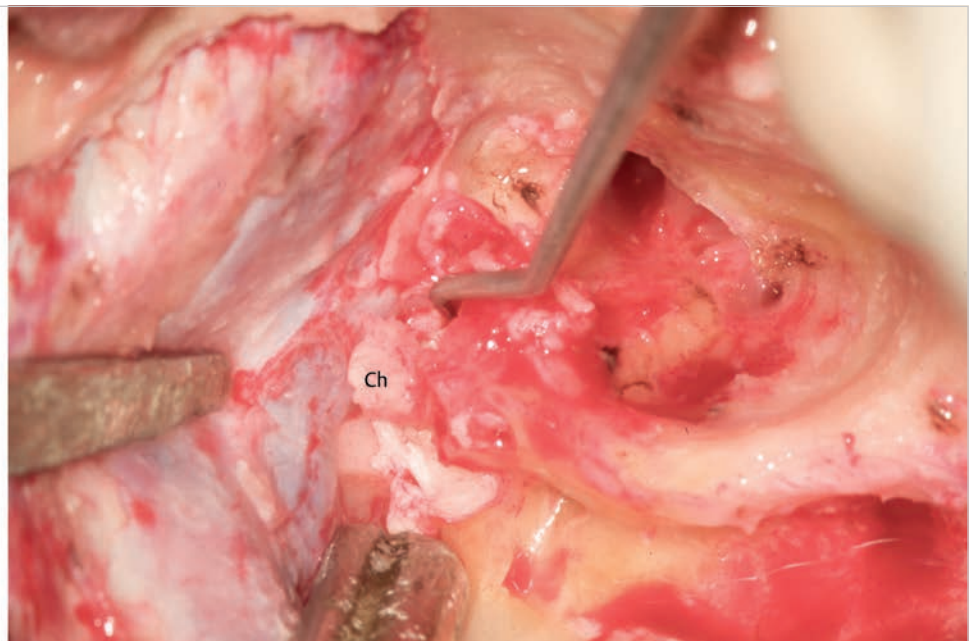
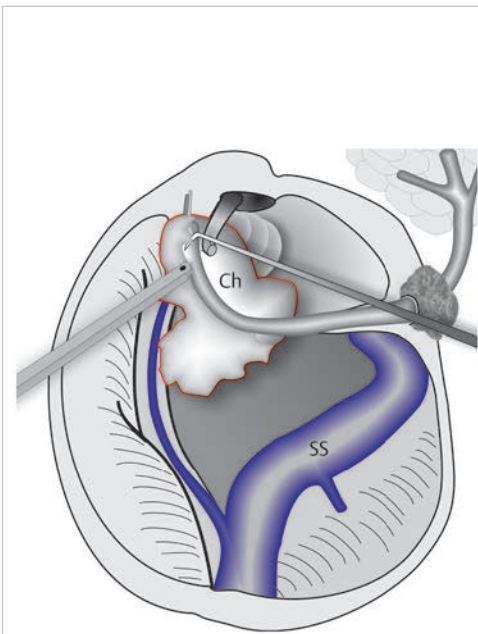


Fig. 14.152 Debulking of cholesteatoma under the facial nerve is conducted with a hook taking care not to insult the labyrinthine segment of the nerve. Ch, cholesteatoma; SS, sigmoid sinus.

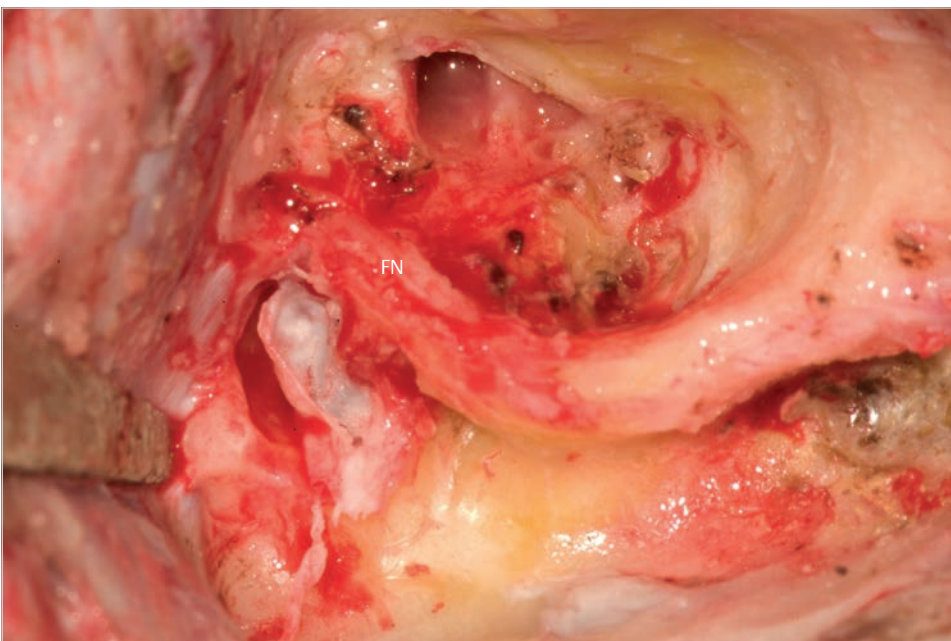


Fig. 14.153 Dissection of the matrix is started from superior, from the middle fossa dura. The matrix covers the superior face of the internal auditory canal. FN, facial nerve.

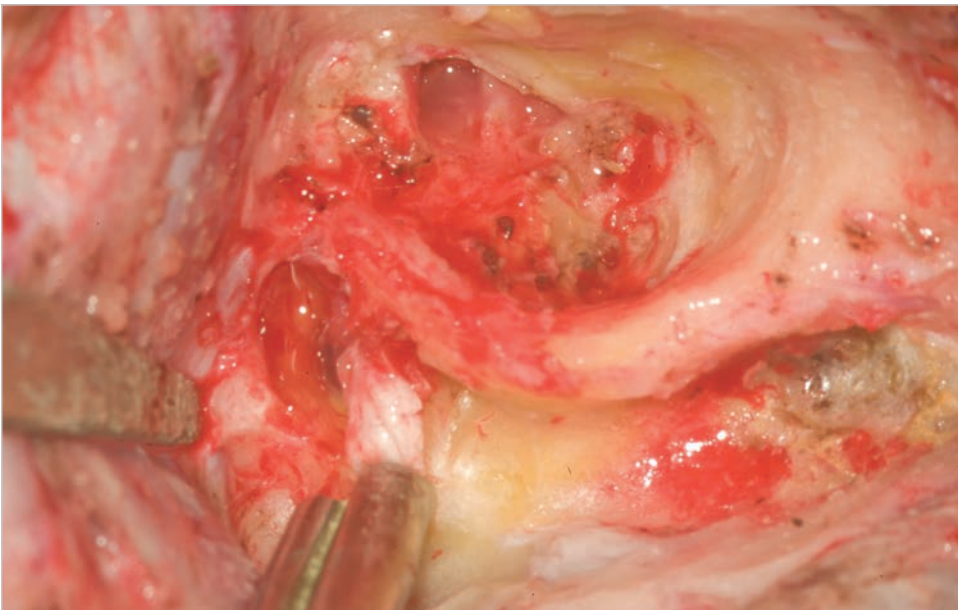


Fig. 14.154 The matrix is detached from the internal auditory canal by pulling it with the suction irrigator.



Fig. 14.155 Removal of the matrix exposed the superior face of the internal auditory canal (arrow). Cerebrospinal fluid leaking from the fundus is seen. FN, facial nerve.

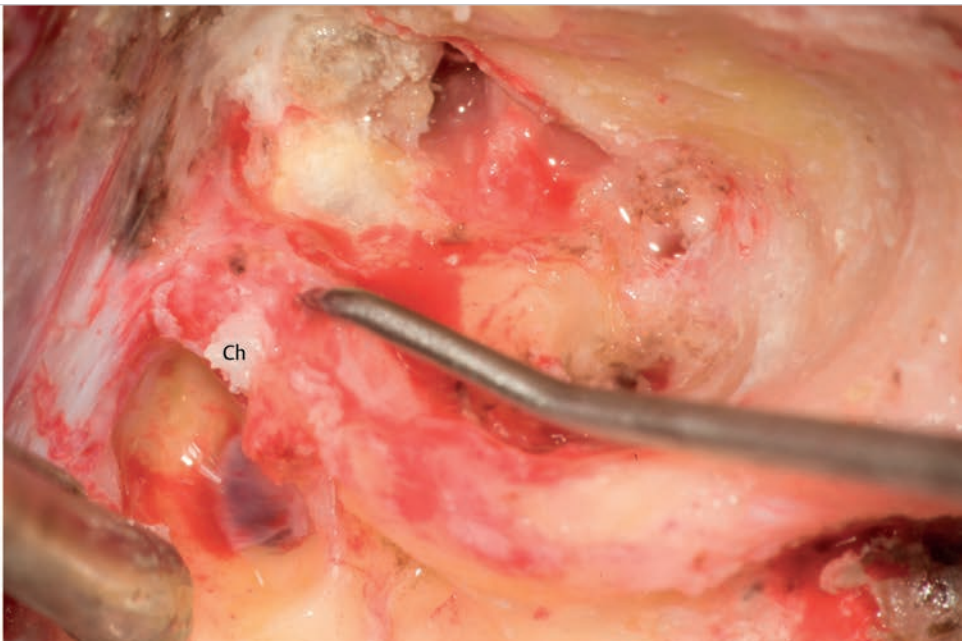
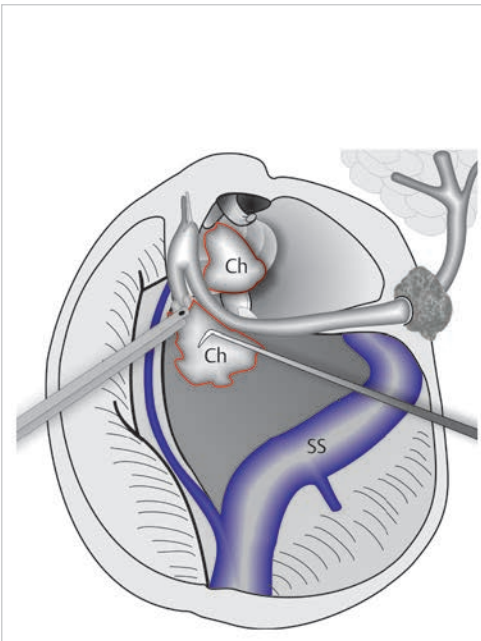


Fig. 14.156 The geniculate ganglion is pushed inferiorly to see better the cholesteatoma and the labyrinthine segment of the facial nerve. Ch, cholesteatoma.

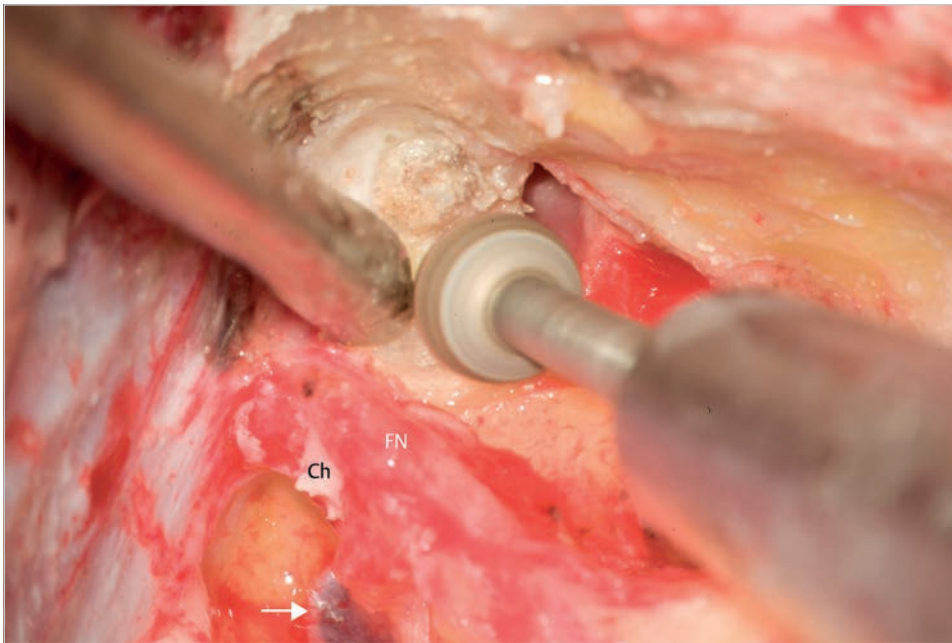


Fig. 14.157 To control inferior margin of the cholesteatoma, the cochlea is drilled. Very thin dura near the fundus of the internal auditory canal is seen (*arrow*). Ch, cholesteatoma; FN, facial nerve.



Fig. 14.158 The inferior margin of cholesteatoma infiltrating the bone under the facial nerve between the cochlea and the vestibule is shown (*arrow*). An opening of the apical turn of the cochlea is seen under the suction. Ch, cholesteatoma; FN, facial nerve.

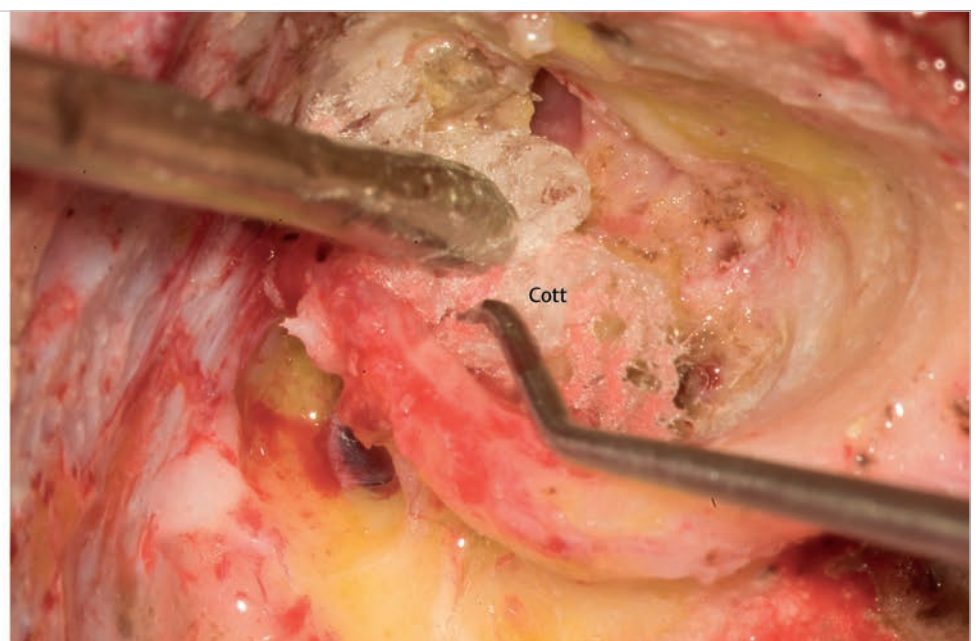
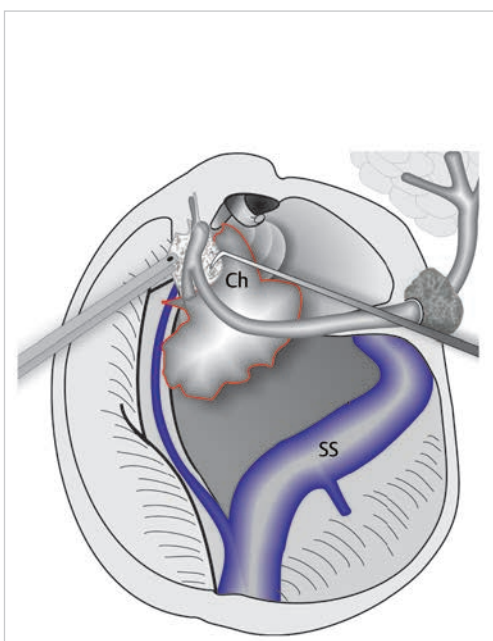


Fig. 14.159 The matrix under the geniculate ganglion is cleaned with cottonoid. Ch, cholesteatoma; Cott, cottonoid; SS, sigmoid sinus.

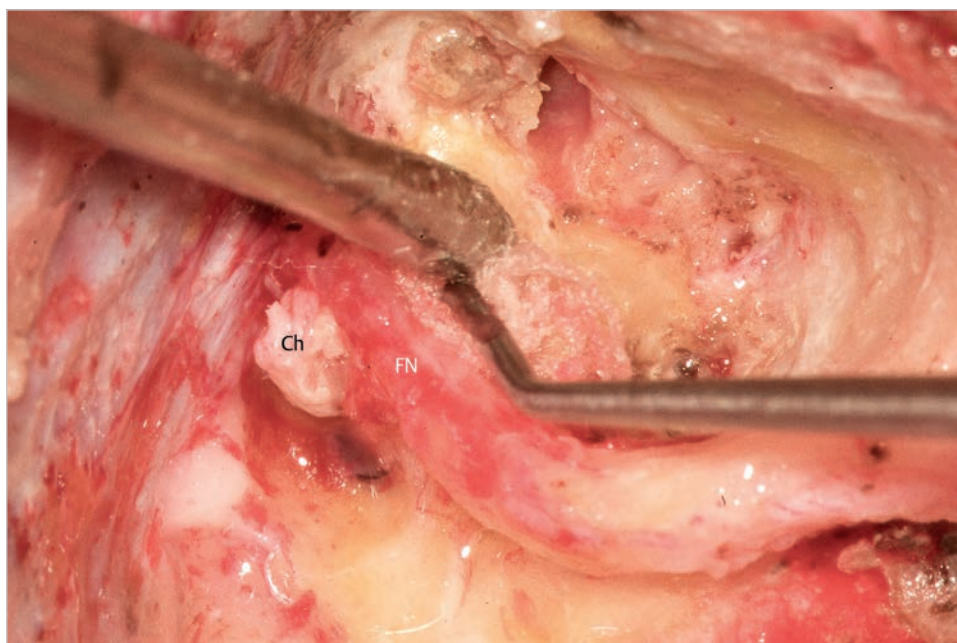


Fig. 14.160 The matrix of the cholesteatoma invaginating under the geniculate ganglion anteriorly to the labyrinthine segment is gently pushed out with the help of cottonoid. Ch, cholesteatoma; FN, facial nerve.

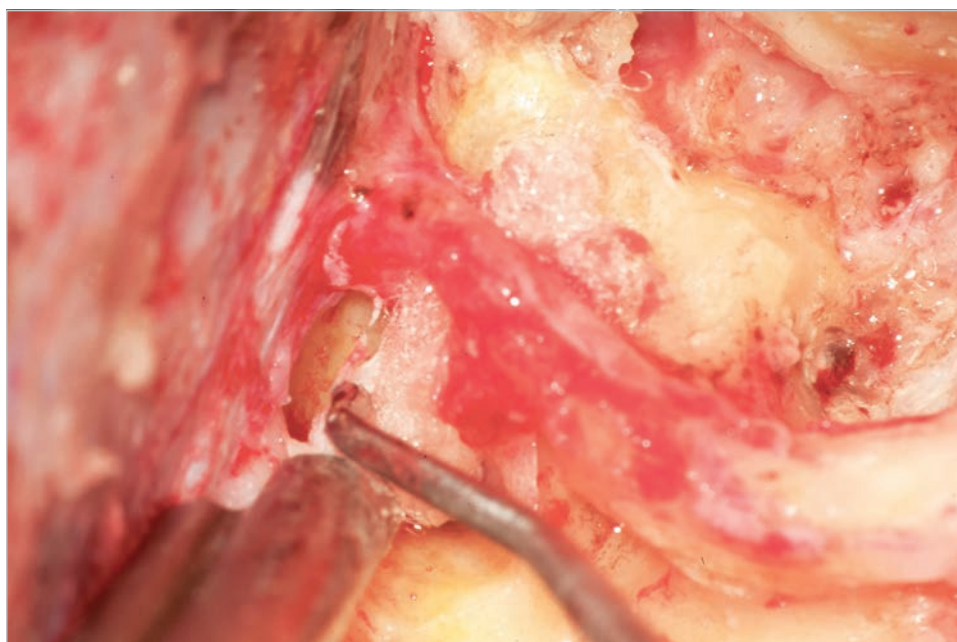


Fig. 14.161 Remaining matrix covering the facial nerve is carefully dissected.

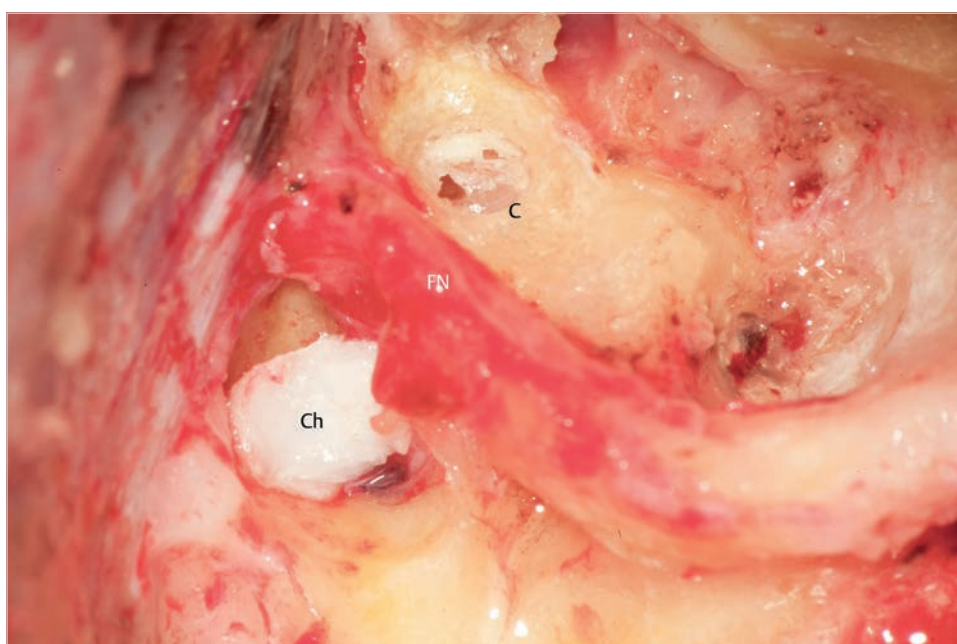


Fig. 14.162 The cholesteatoma posteriorly to the labyrinthine segment is adherent to the facial nerve. C, cochlea; Ch, cholesteatoma; FN, facial nerve.

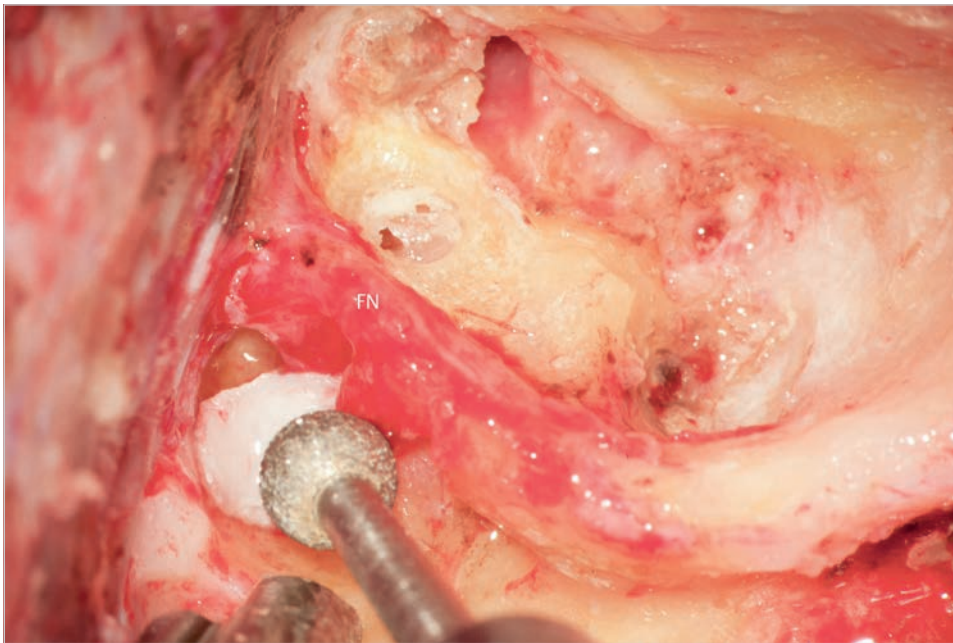


Fig. 14.163 To establish better access to the labyrinthine segment and the fundus of the internal auditory canal, the posterosuperior wall of the internal auditory canal corresponding to the anterosuperior wall of the vestibule is removed with a large diamond burr. FN, facial nerve.

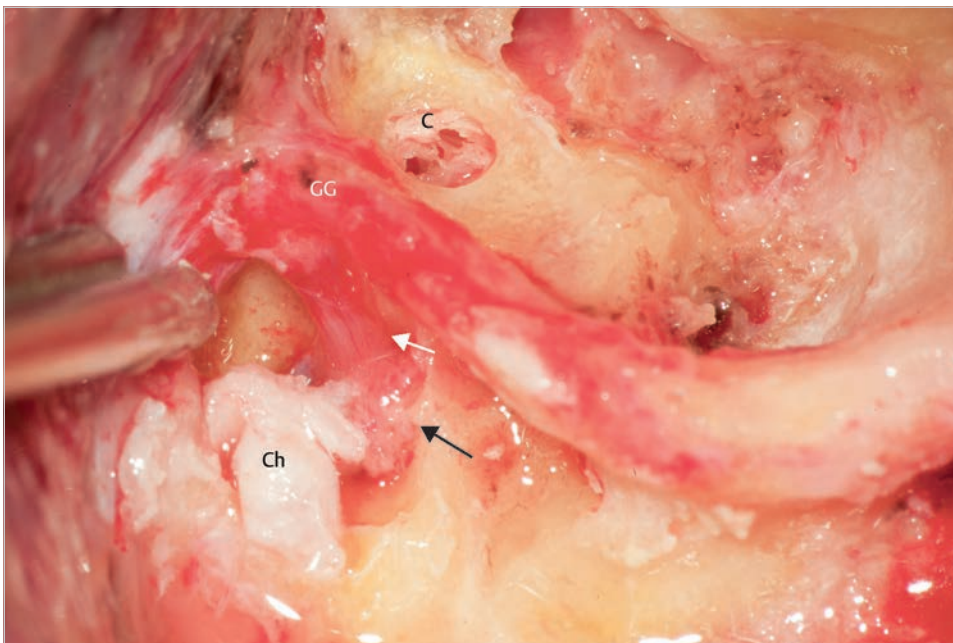


Fig. 14.164 The cholesteatoma is dissected from the posterior face of the labyrinthine segment (*white arrow*). Transected vestibular nerve (*black arrow*) is seen posteriorly to the facial nerve. C, cochlea; Ch, cholesteatoma; GG, geniculate ganglion.

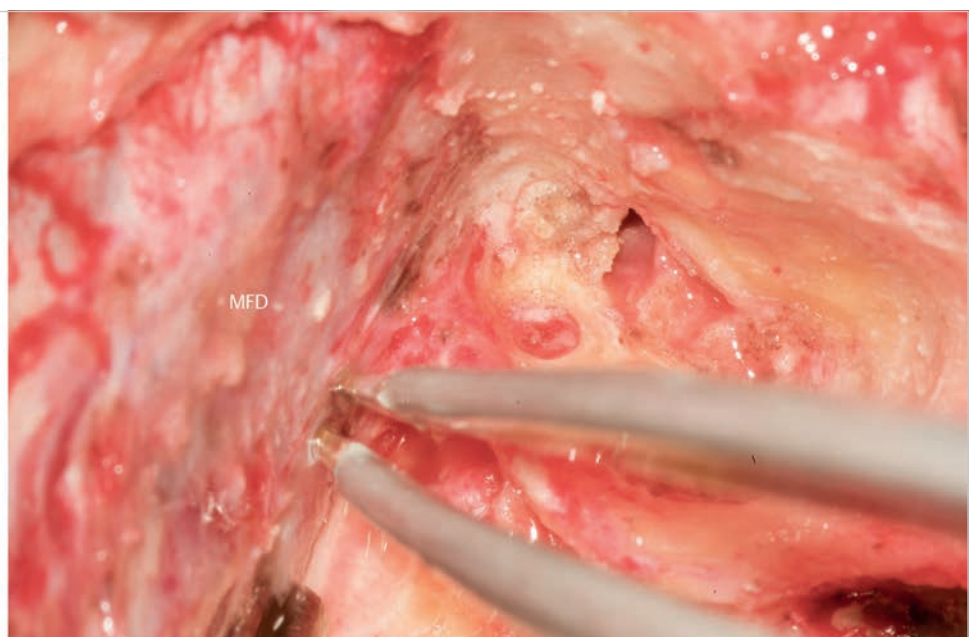
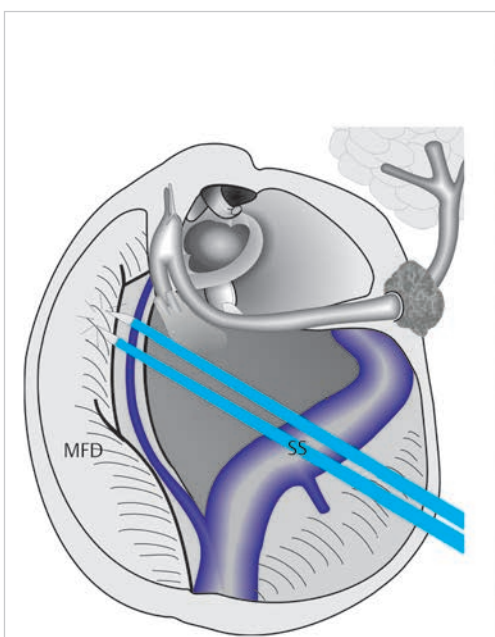


Fig. 14.165 The dura suspicious of residual matrix should be coagulated with bipolar. MFD, middle fossa dura.

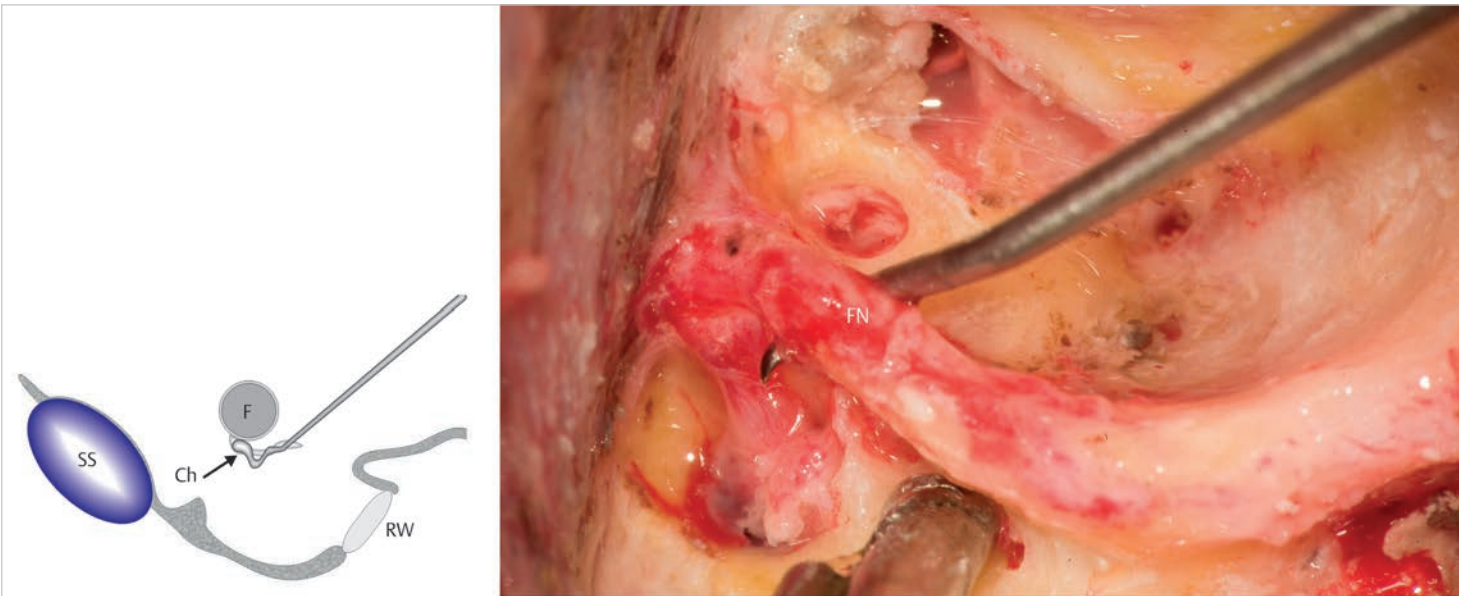


Fig. 14.166 The medial face of the facial nerve is cleaned with a tympanic sinus hook. Ch, cholesteatoma; F, abdominal fat; FN, facial nerve; RW, round window; SS, sigmoid sinus.

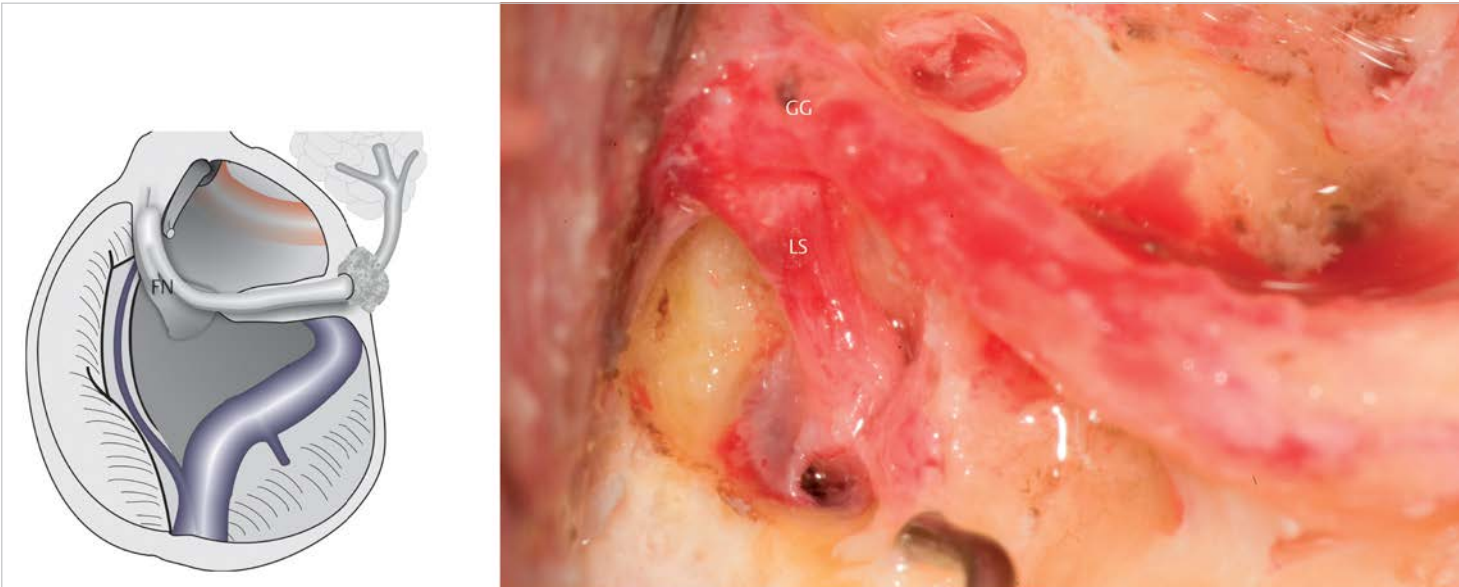


Fig. 14.167 The anterosuperior part of the fundus of the internal auditory canal is under control. FN, facial nerve; GG, geniculate ganglion; LS, labyrinthine segment of facial nerve.



Fig. 14.168 The suspicious area anteriorly to the labyrinthine segment is scrubbed with cottonoid. SS, sigmoid sinus.



Fig. 14.169 Complete removal of cholesteatoma is checked by pushing the labyrinthine segment of the facial nerve inferiorly. FN, facial nerve.



Fig. 14.170 The opening of the internal auditory canal is gently closed, and the eustachian tube is tightly packed with periosteum. FN, facial nerve; Po, periosteum.

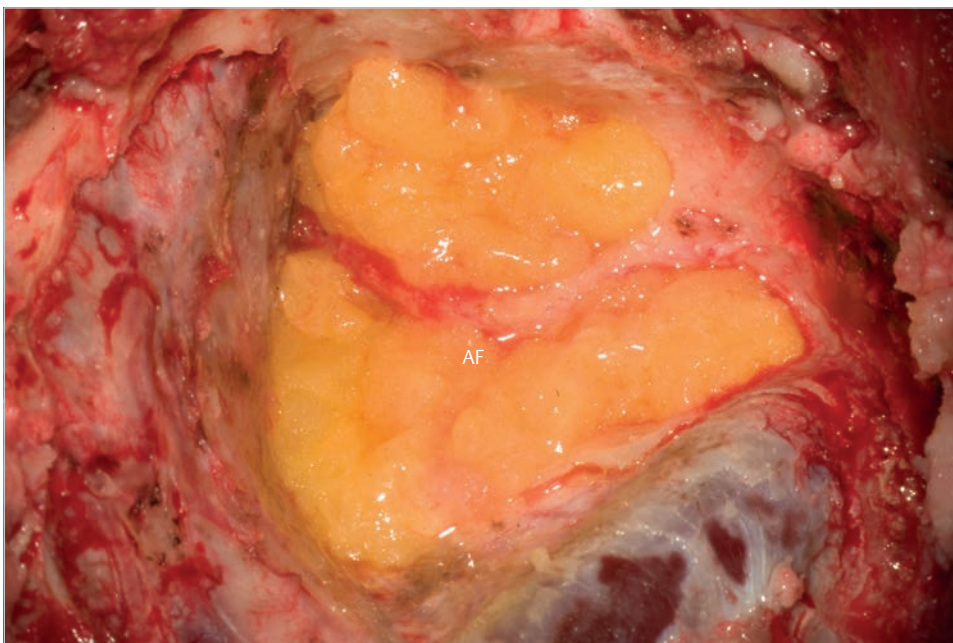


Fig. 14.171 The cavity is obliterated with abdominal fat. AF, abdominal fat.

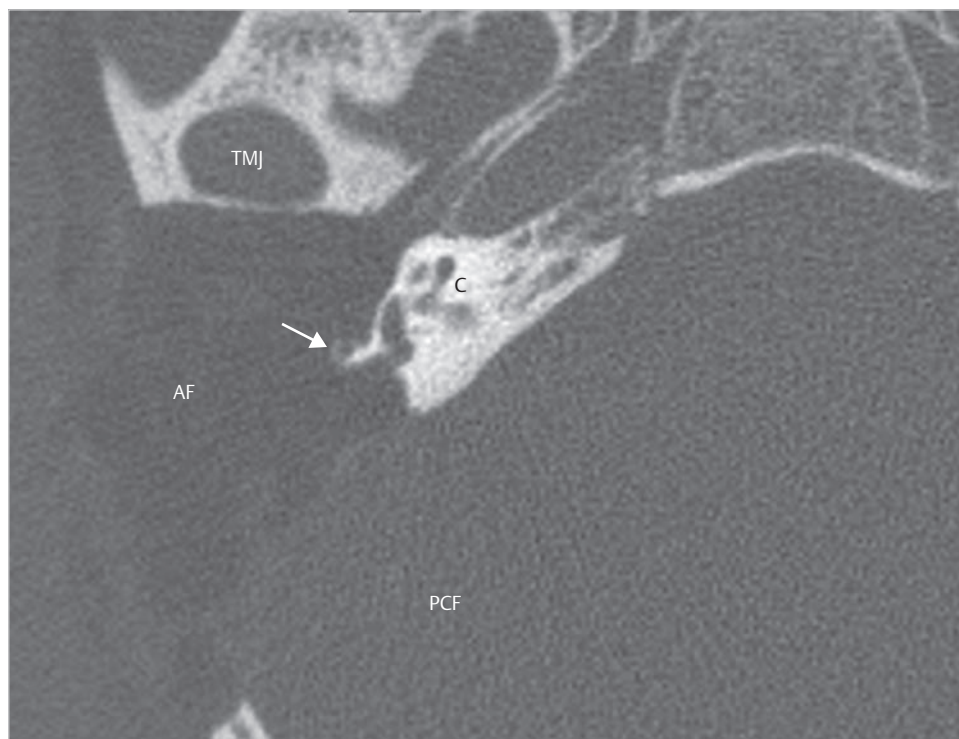


Fig. 14.172 The postoperative axial CT demonstrates extensive removal of the posterior labyrinth. The cochlea partially drilled posterolaterally keeps its shape at this level. The mastoid segment of the facial nerve is identified just posteriorly to the cochlea (*arrow*). AF, abdominal fat; C, cochlea; PCF, posterior cranial fossa; TMJ, temporomandibular joint.

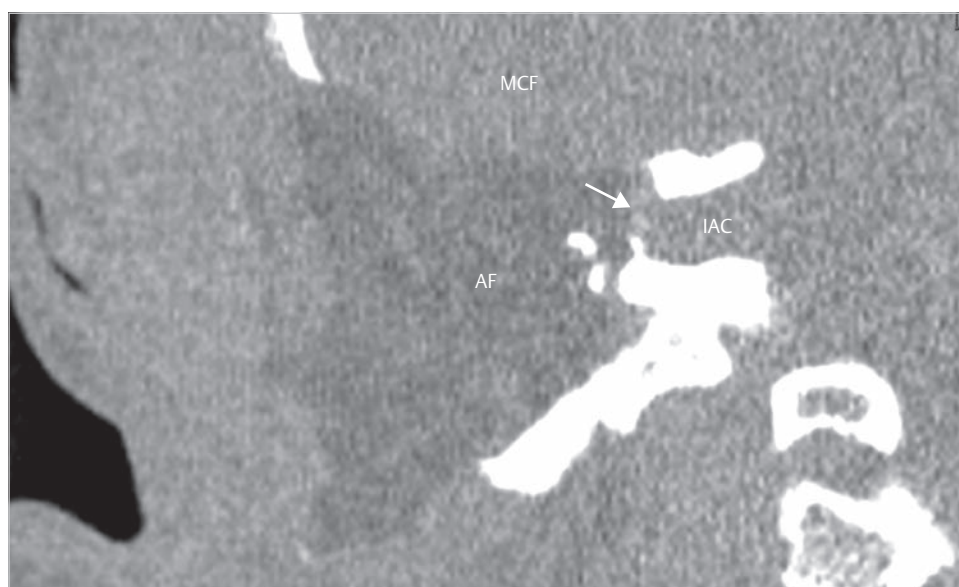


Fig. 14.173 The postoperative coronal CT demonstrates extensive exposure of the middle fossa dura and opening of the internal auditory canal at the fundus (*arrow*). AF, abdominal fat; IAC, internal auditory canal; MCF, middle cranial fossa.

Case 14.7 (Right Ear)

See ►Fig. 14.174, ►Fig. 14.175, ►Fig. 14.176, ►Fig. 14.177, ►Fig. 14.178, ►Fig. 14.179, ►Fig. 14.180, ►Fig. 14.181, ►Fig. 14.182, ►Fig. 14.183, ►Fig. 14.184, ►Fig. 14.185, ►Fig. 14.186, ►Fig. 14.187, ►Fig. 14.188, ►Fig. 14.189, ►Fig. 14.190, ►Fig. 14.191, ►Fig. 14.192, ►Fig. 14.193, ►Fig. 14.194, ►Fig. 14.195.

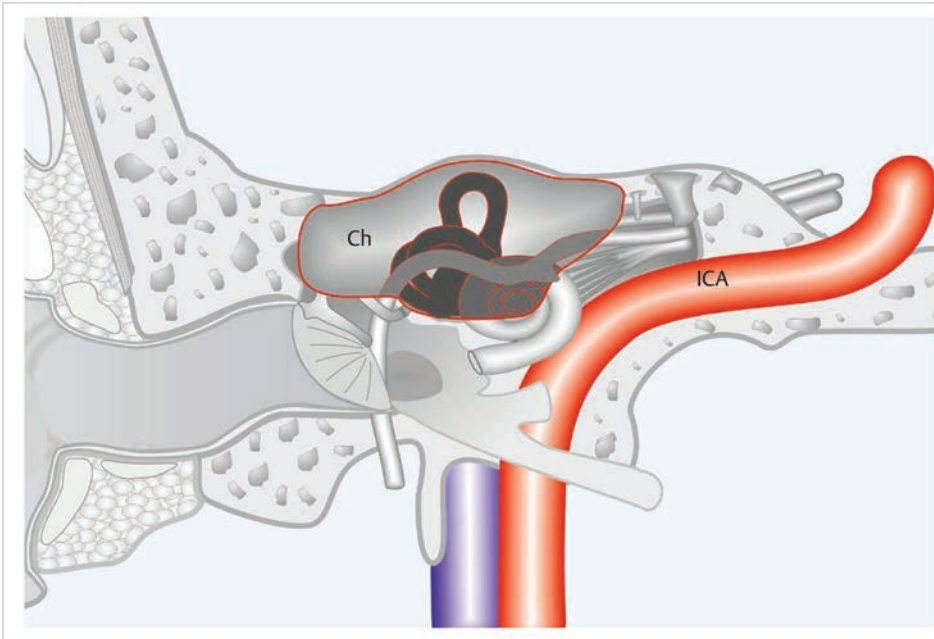


Fig. 14.174 A case of congenital supralabyrinthine petrous bone cholesteatoma eroding the cochlea, the vestibule, and the internal auditory canal removed with transotic approach. Ch, cholesteatoma; ICA, internal carotid artery.

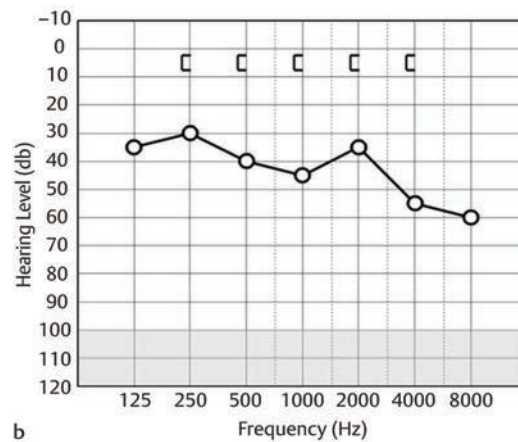


Fig. 14.175 The otoscopy shows middle ear effusion in the tympanic cavity. The pars flaccida forms retraction pocket, but no evidence of cholesteatoma is identified. The audiogram shows conductive hearing loss with good bone conduction comparable to the contralateral ear. No dizziness is experienced, and the facial nerve function remains normal.

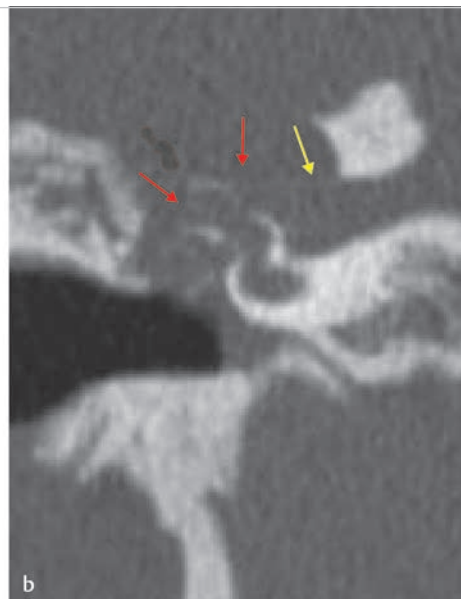
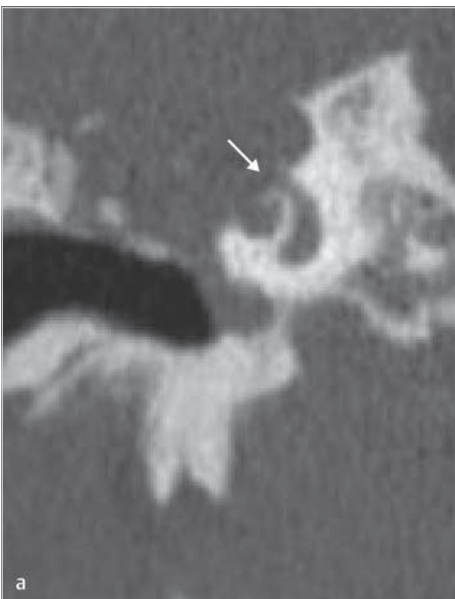


Fig. 14.176 In spite of good inner ear function, and modest otoscopic findings, the coronal CT scans show extensive erosion in the cochlea (white arrow), semicircular canals (red arrows), and the internal auditory canal (yellow arrow).

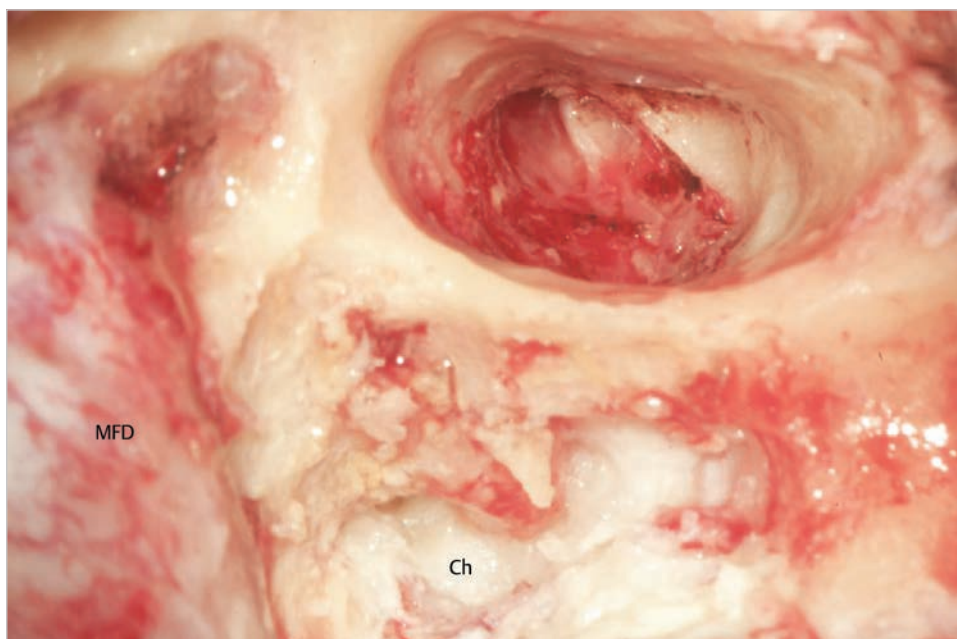


Fig. 14.177 The meatal skin and the tympanic membrane are removed, and the external auditory canal is closed. The middle fossa dura is exposed to manage the cholesteatoma eroding the labyrinth from superior. The cholesteatoma filling the mastoid cavity with limited extension to the tympanic cavity is seen. Ch, cholesteatoma; MFD, middle fossa dura.

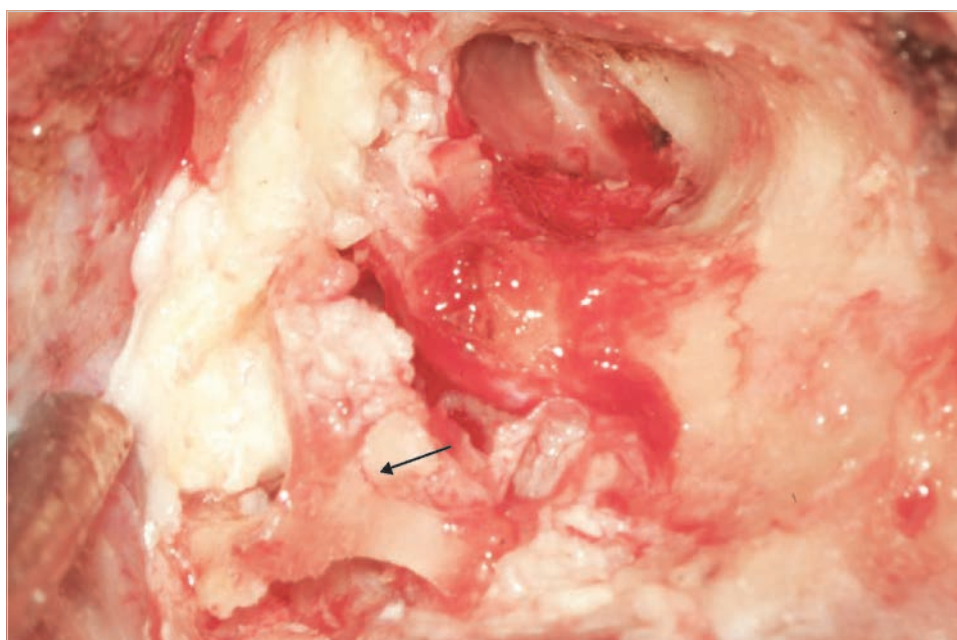


Fig. 14.178 The posterior wall is lowered, and the attic is opened. The attic is filled with cholesteatoma. Bone covering the matrix at the medial wall of the antrum (*arrow*) is removed with a curette.

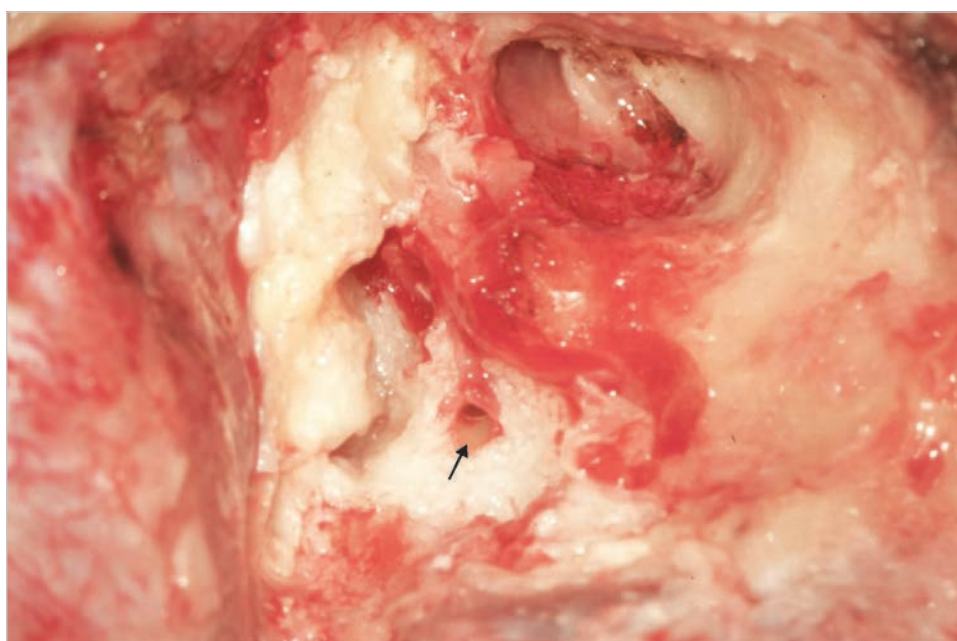


Fig. 14.179 The semicircular canals are totally engulfed by the cholesteatoma. The posterior end of the lateral semicircular canal is seen (*arrow*).

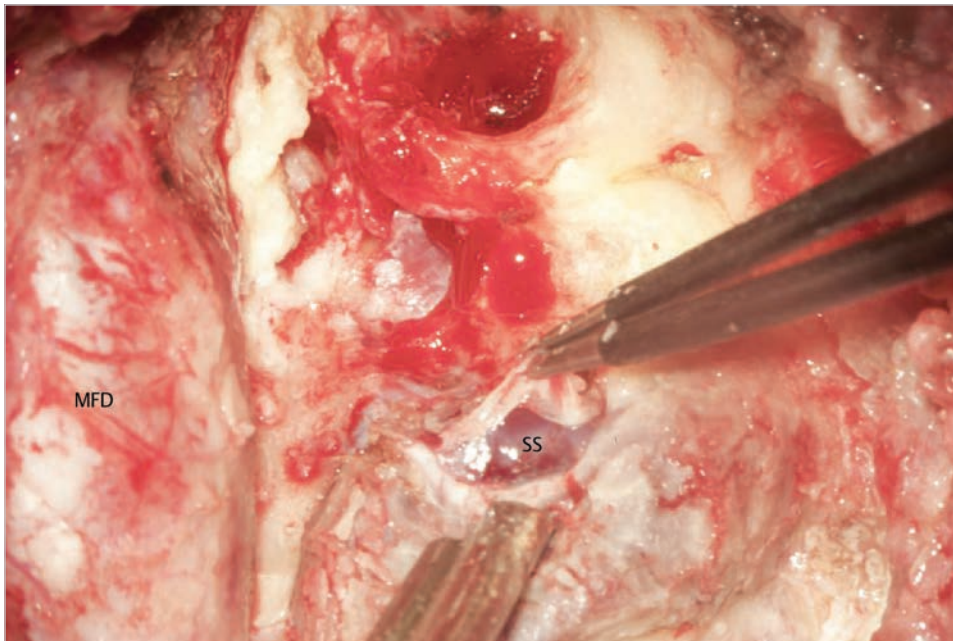


Fig. 14.180 Posteriorly, the sigmoid sinus and the posterior fossa dura are extensively exposed by the cholesteatoma. The matrix is carefully dissected with meticulous care not to tear these structures. MFD, middle fossa dura; SS, sigmoid sinus.

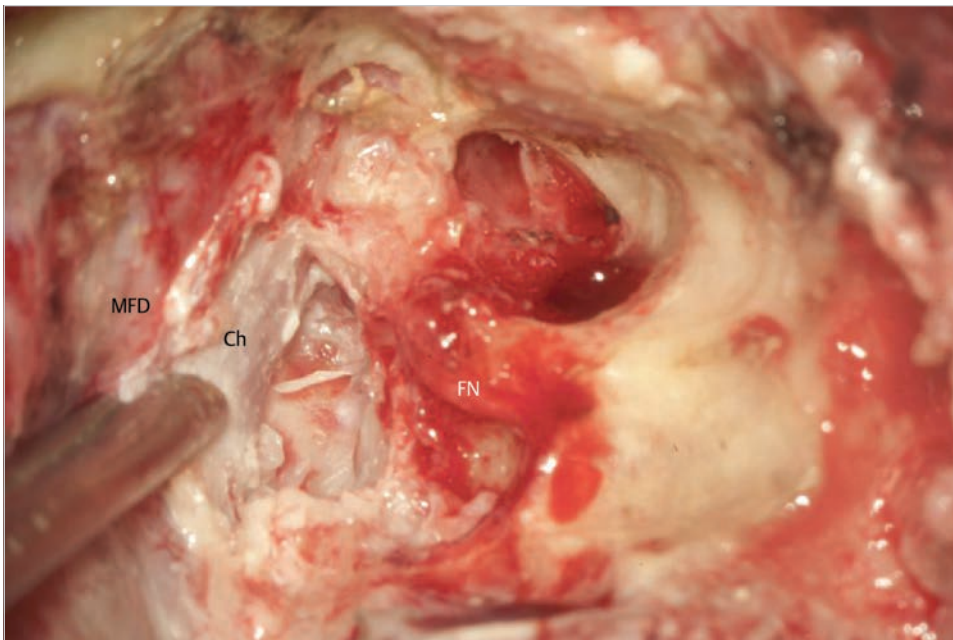


Fig. 14.181 The matrix eroding the posterior labyrinth is shown. Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura.



Fig. 14.182 The matrix is removed from the area of the posterior labyrinth. The vestibule (yellow arrow) and the inferior end of the posterior semicircular canal (white arrow) are seen. The facial nerve is widely exposed by the cholesteatoma. FN, facial nerve.

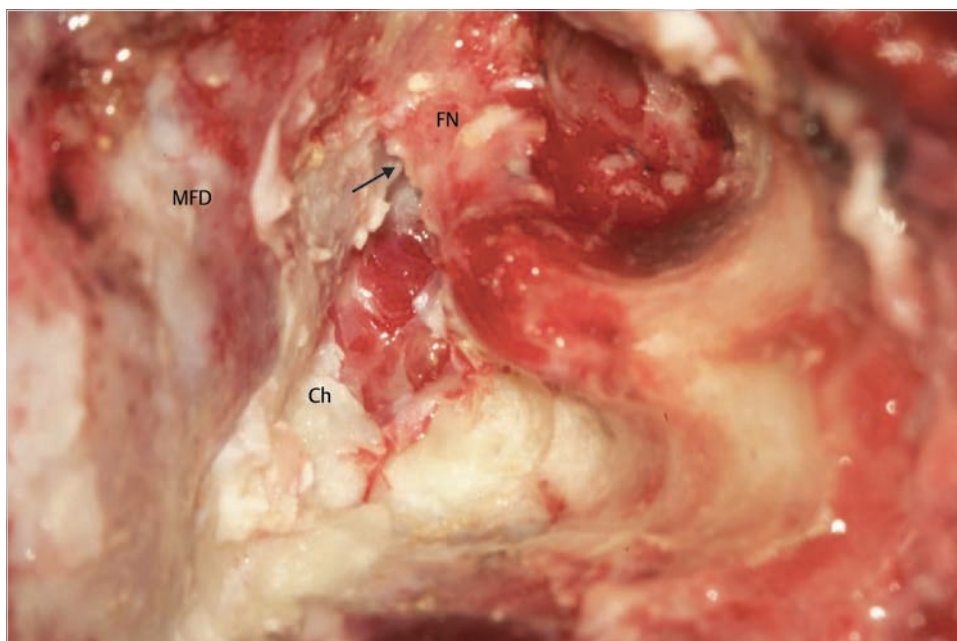


Fig. 14.183 Labyrinthectomy is completed. The cholesteatoma deeply infiltrating the medial wall of the attic to reach the superior face of the cochlea is visualized (*arrow*). Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura.

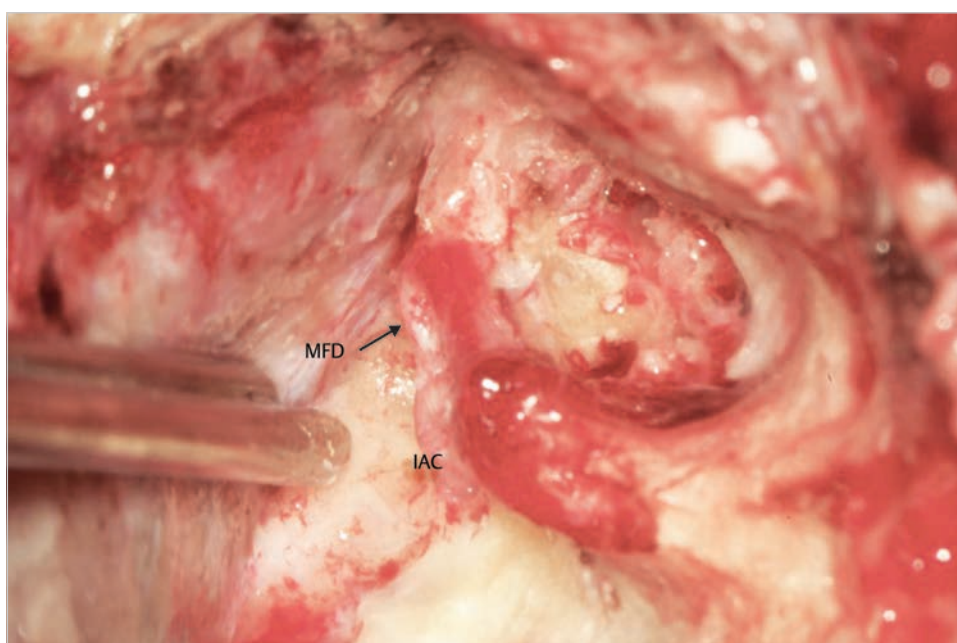


Fig. 14.184 The majority of the cholesteatoma matrix eroding the medial wall of the attic is removed. The labyrinthine segment of the facial nerve (*arrow*) and the superior aspect of the internal auditory canal exposed under the matrix are seen. To access inferior margin of cholesteatoma, the cochlea is started to be drilled. IAC, internal auditory canal; MFD, middle fossa dura.

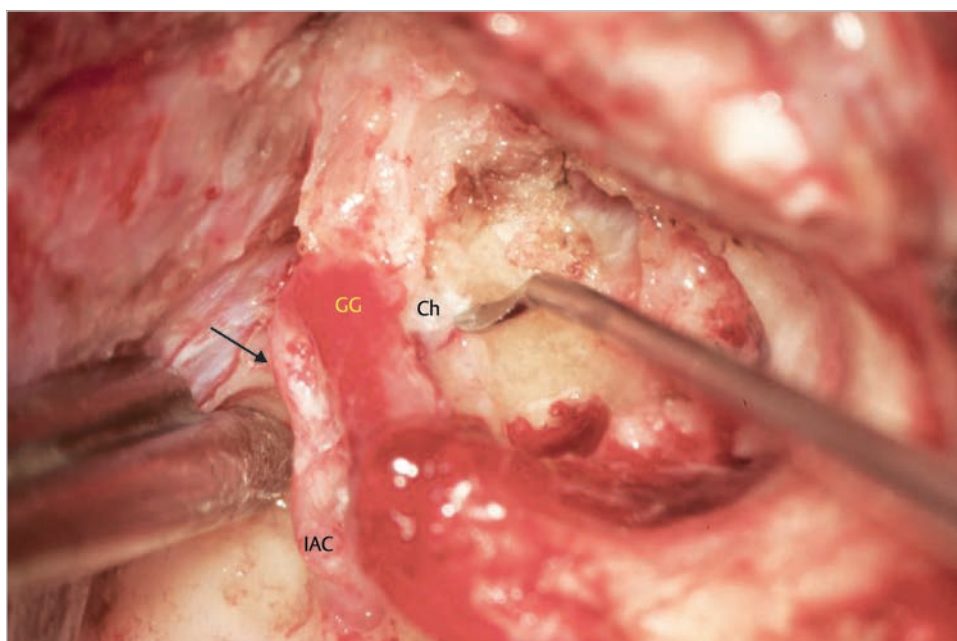


Fig. 14.185 The inferior margin of cholesteatoma infiltrating the bone under the geniculate ganglion and the cochlea is shown. The labyrinthine segment of the facial nerve (*arrow*) connects the geniculate ganglion with the internal auditory canal. Ch, cholesteatoma; GG, geniculate ganglion; IAC, internal auditory canal.

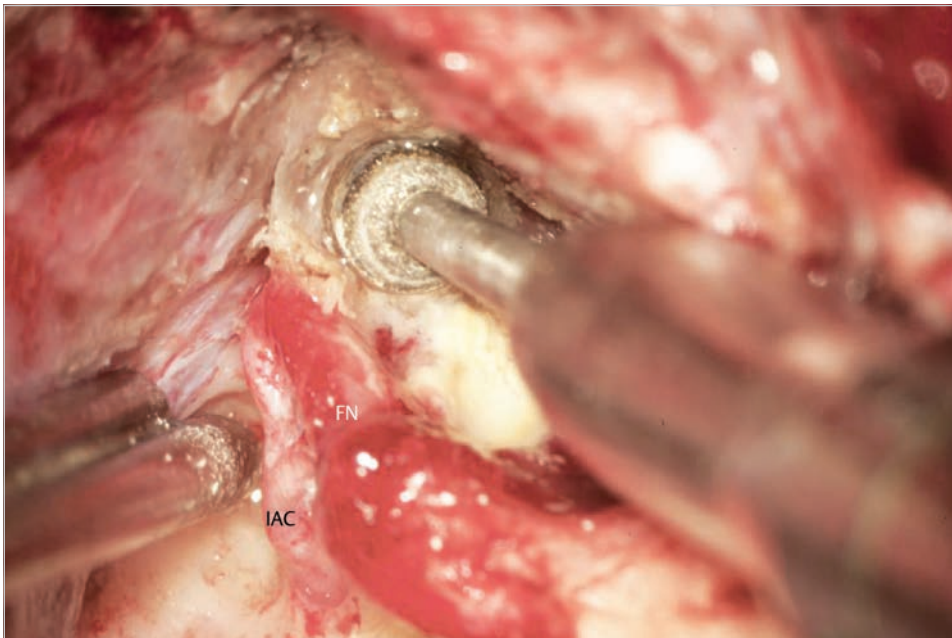


Fig. 14.186 To enlarge access to the cholesteatoma under the facial nerve, the cochlea, together with the bone covering the geniculate ganglion, is removed taking care not to damage the great superficial petrosal nerve. FN, facial nerve; IAC, internal auditory canal.

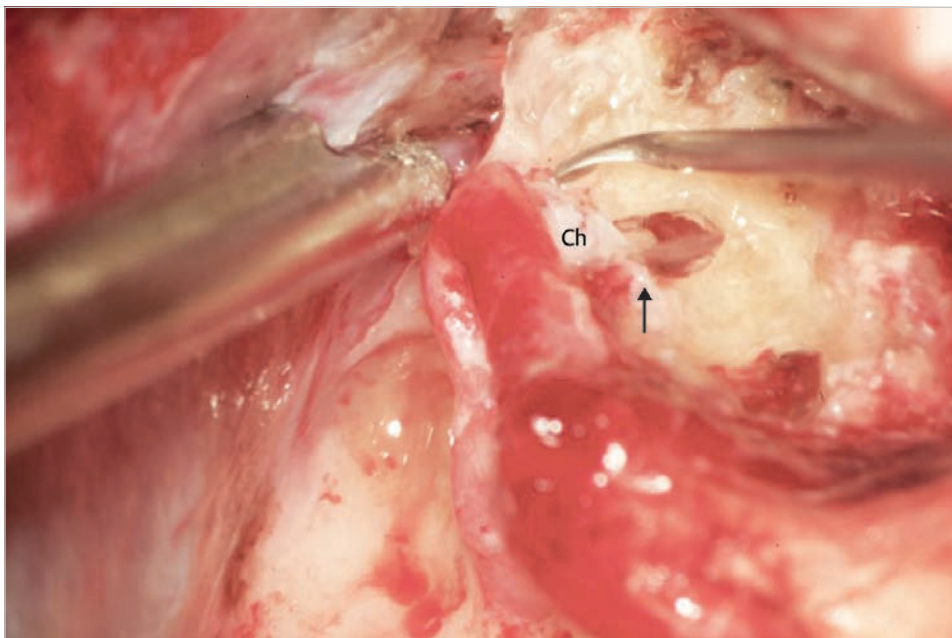


Fig. 14.187 The apical turn of the cochlea is opened to expose the inferior margin of the cholesteatoma eroding the cochlea (*arrow*). Ch, cholesteatoma.

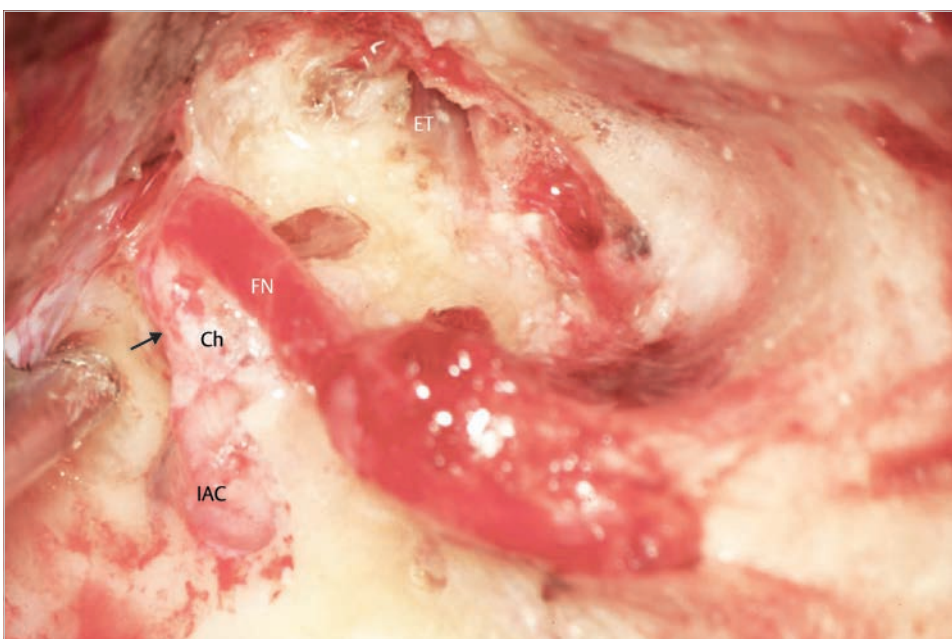


Fig. 14.188 The cholesteatoma under the facial nerve, posteriorly to the labyrinthine segment (*arrow*) is shown. Ch, cholesteatoma; ET, eustachian tube; FN, facial nerve; IAC, internal auditory canal.

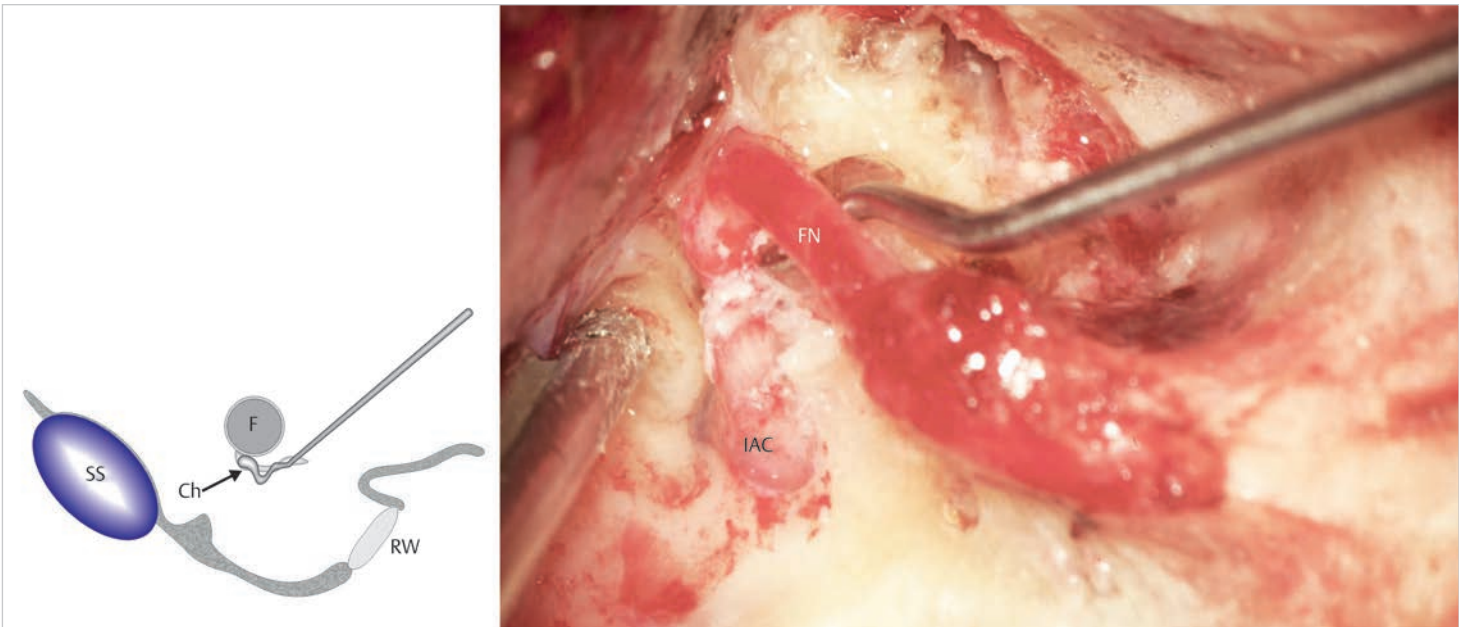


Fig. 14.189 The matrix of the cholesteatoma is dissected from the medial face of the facial nerve with the tympanic sinus hook. Ch, cholesteatoma; F, abdominal fat; FN, facial nerve; IAC, internal auditory canal; RW, round window; SS, sigmoid sinus.

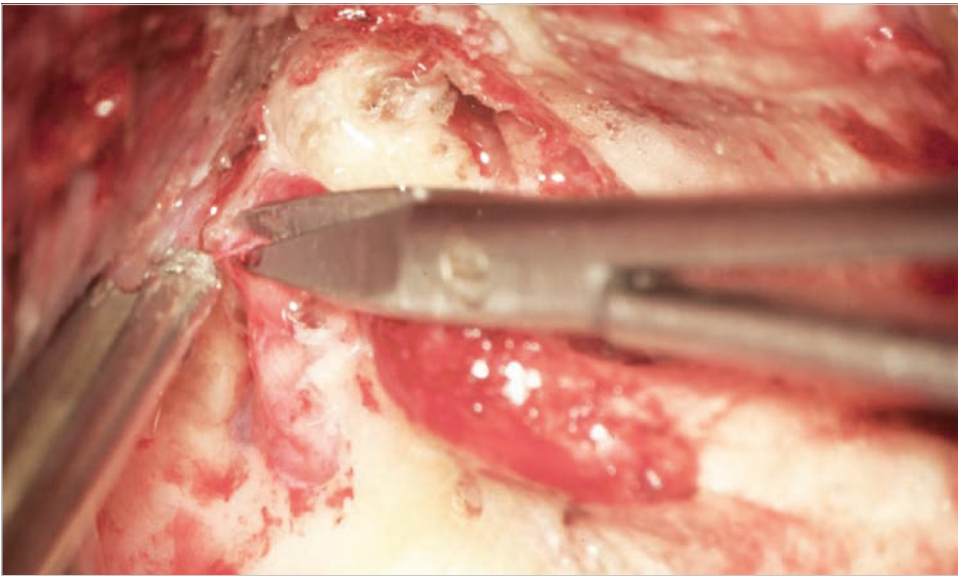


Fig. 14.190 Removal of the matrix adherent to the facial nerve sometimes requires sharp dissection.

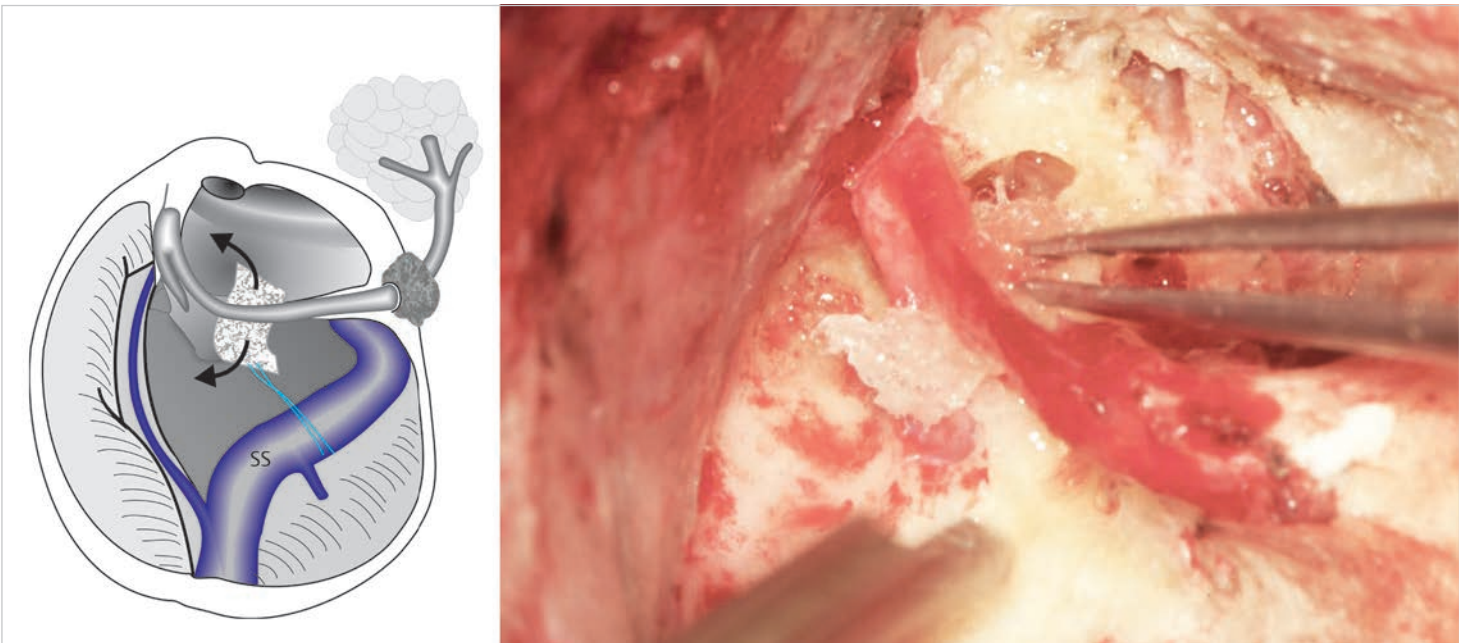


Fig. 14.191 The area suspicious of complete removal of the matrix is scrubbed with cottonoid taking care not to damage the facial nerve. SS, sigmoid sinus.

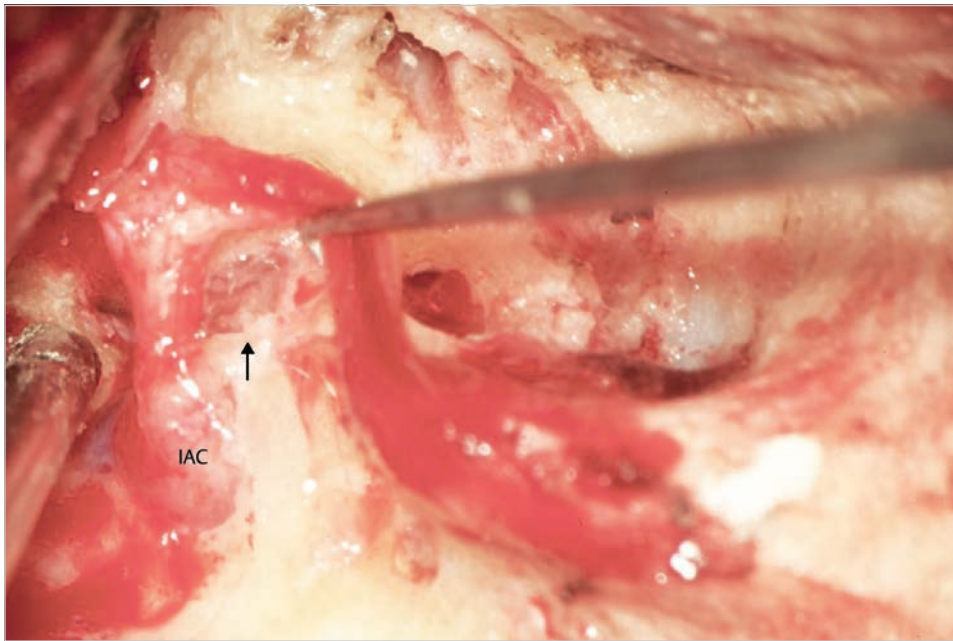


Fig. 14.192 The tympanic segment of the facial nerve is pushed inferiorly to verify absence of skin under the facial nerve. The second turn of the cochlea is seen (arrow). IAC, internal auditory canal.

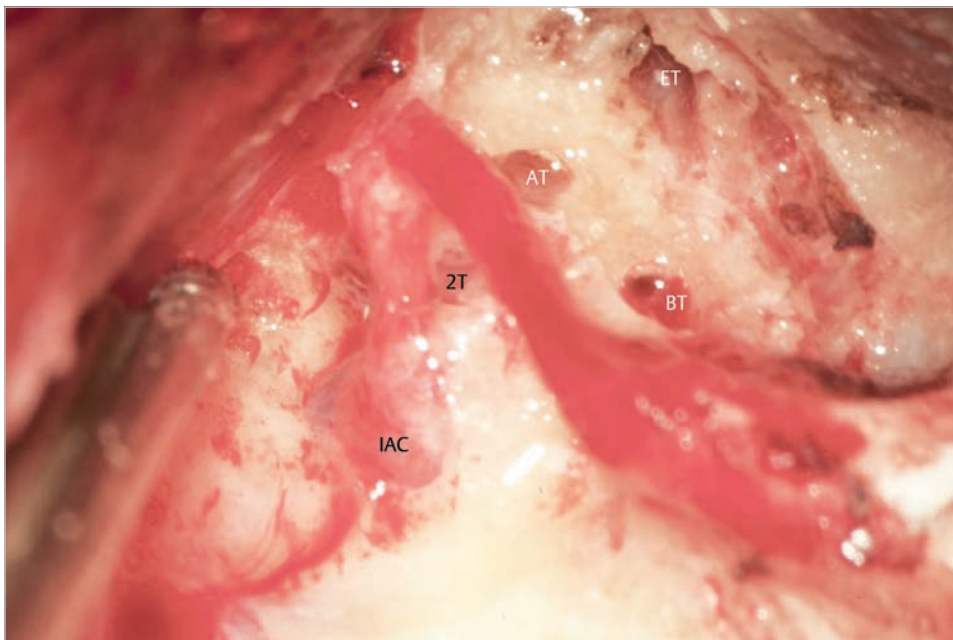


Fig. 14.193 The final shape of the area around the facial nerve is shown. AT, apical turn of cochlea; BT, basal turn of cochlea; ET, eustachian tube; IAC, internal auditory canal; 2T, second turn of cochlea.

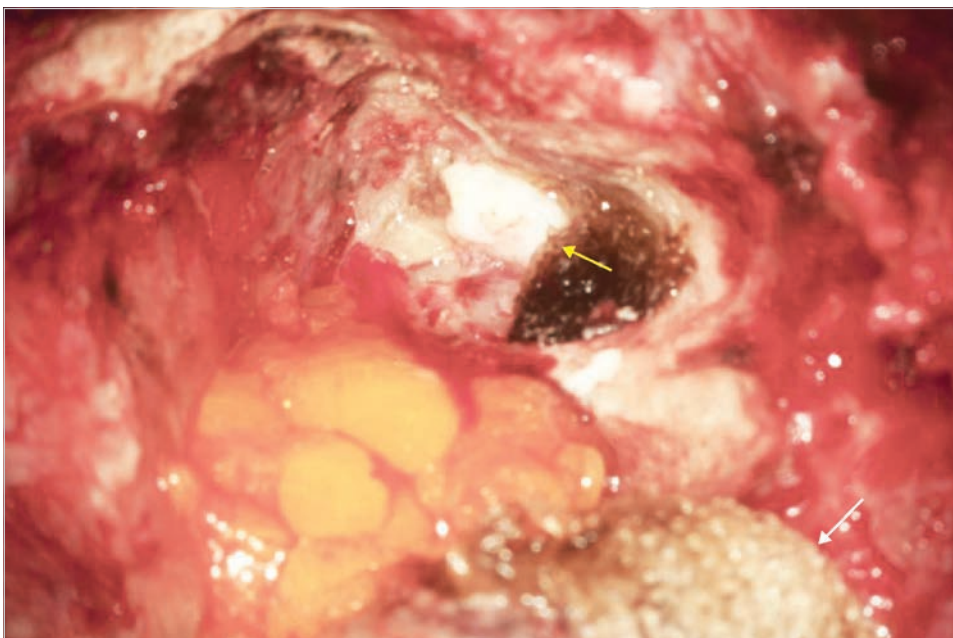


Fig. 14.194 Bleeding from the sigmoid sinus can be managed with surgical left over the sinus for some period (white arrow). The eustachian tube is closed with periosteum (yellow arrow), and the cavity is obliterated with abdominal fat. The facial nerve function remained normal postoperatively.

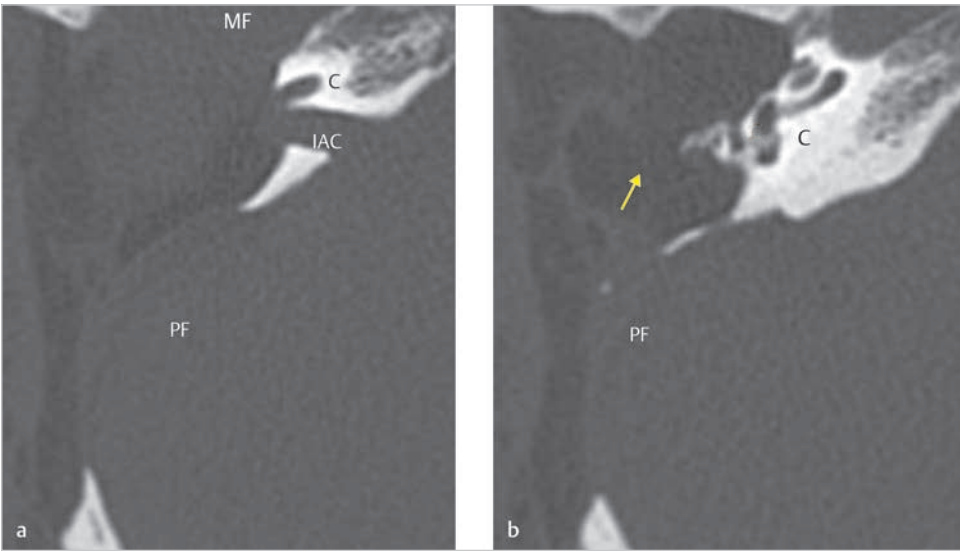


Fig. 14.195 Postoperative axial CT on the left shows partially drilled cochlea and the internal auditory canal with wide exposure of both the middle and the posterior fossae dura. The facial nerve can be identified (*arrow*) in the more caudal slice (right). C, cochlea; IAC, internal auditory canal; MF, middle fossa; PF, posterior fossa.

Case 14.8 (Right Ear)

See ▶Fig. 14.196, ▶Fig. 14.197, ▶Fig. 14.198, ▶Fig. 14.199, ▶Fig. 14.200, ▶Fig. 14.201, ▶Fig. 14.202, ▶Fig. 14.203, ▶Fig. 14.204, ▶Fig. 14.205, ▶Fig. 14.206, ▶Fig. 14.207, ▶Fig. 14.208, ▶Fig. 14.209.

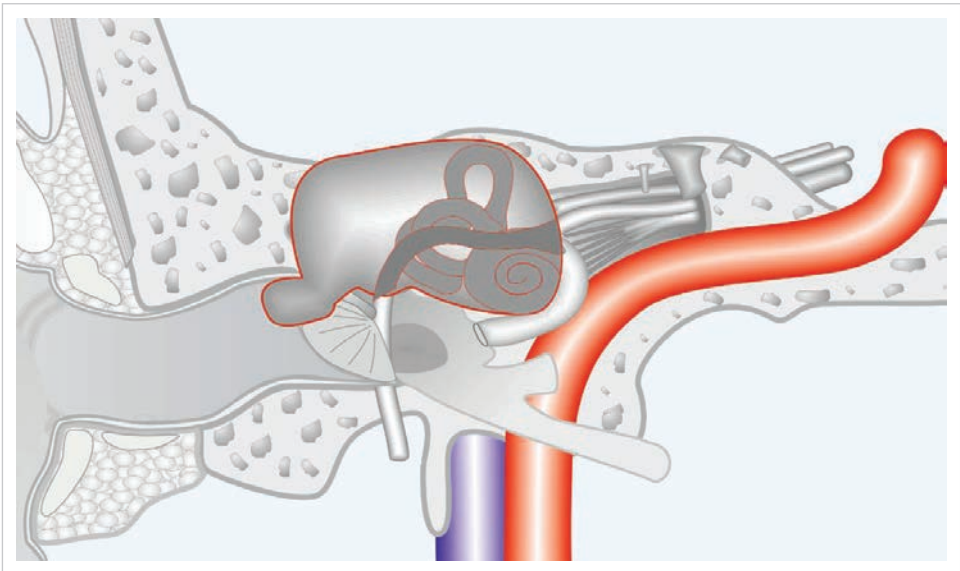


Fig. 14.196 A case of acquired supralabyrinthine petrous bone cholesteatoma eroding both cochlea and the labyrinth with an encasement of the facial nerve removed with subtotal petrosectomy.

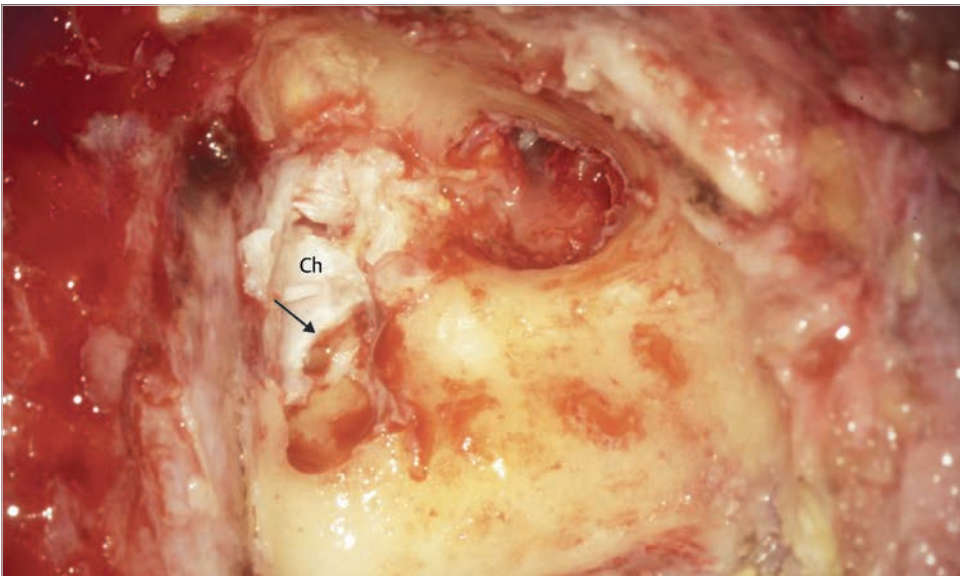


Fig. 14.197 The cholesteatoma invaginating into the middle ear from the posteroinferior quadrant to reach the mastoid is visualized. The external auditory canal is closed in two layers, and canal wall down mastoidectomy is carried out. Removal of the debris from the attic revealed a fistula of the superior semicircular canal (*arrow*). Ch, cholesteatoma.



Fig. 14.198 Closer view. The superior semicircular canal is completely engulfed by the cholesteatoma to form labyrinthine fistula (arrow). Ch, cholesteatoma.

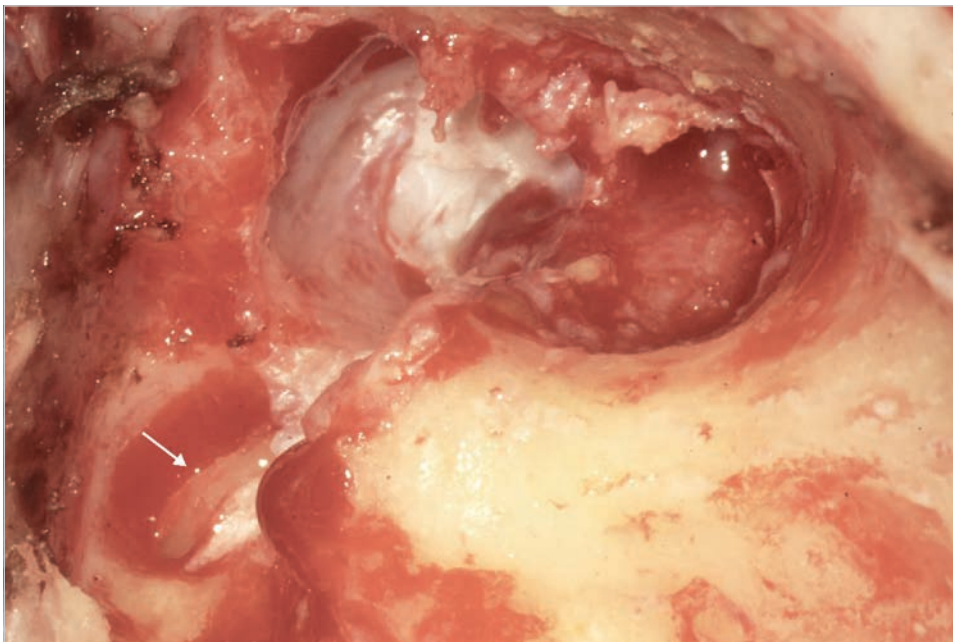


Fig. 14.199 Debris is reduced, and the matrix covering the medial wall is partially removed from the area of the labyrinth. The arrow indicates an opening of the superior semicircular canal.

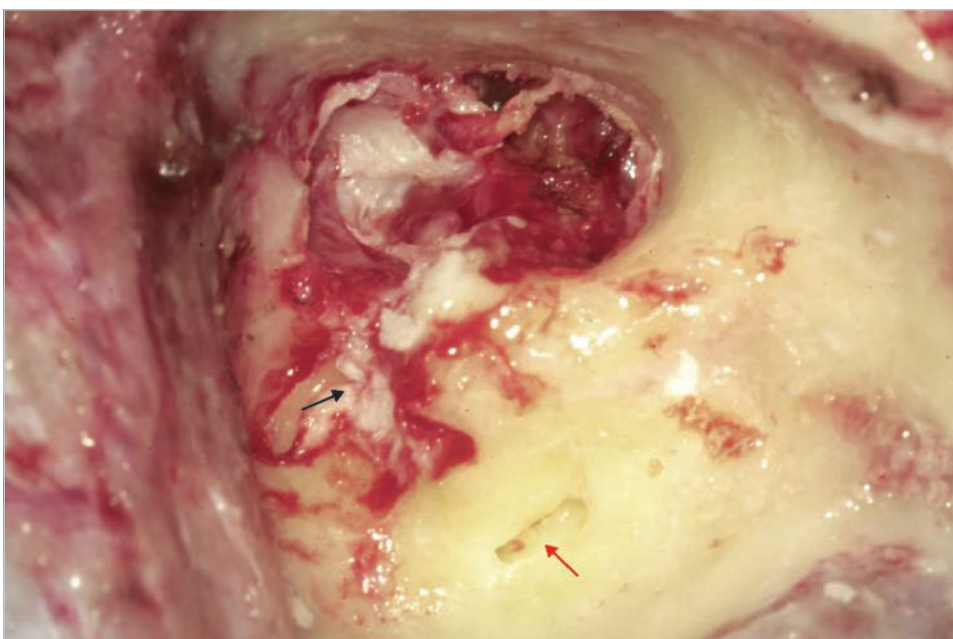


Fig. 14.200 The cholesteatoma infiltrating semicircular canals is shown (black arrow). The posterior semicircular canal is started to be opened (red arrow). Note that the middle fossa dura and the sigmoid sinus are uncovered to maximize approach.

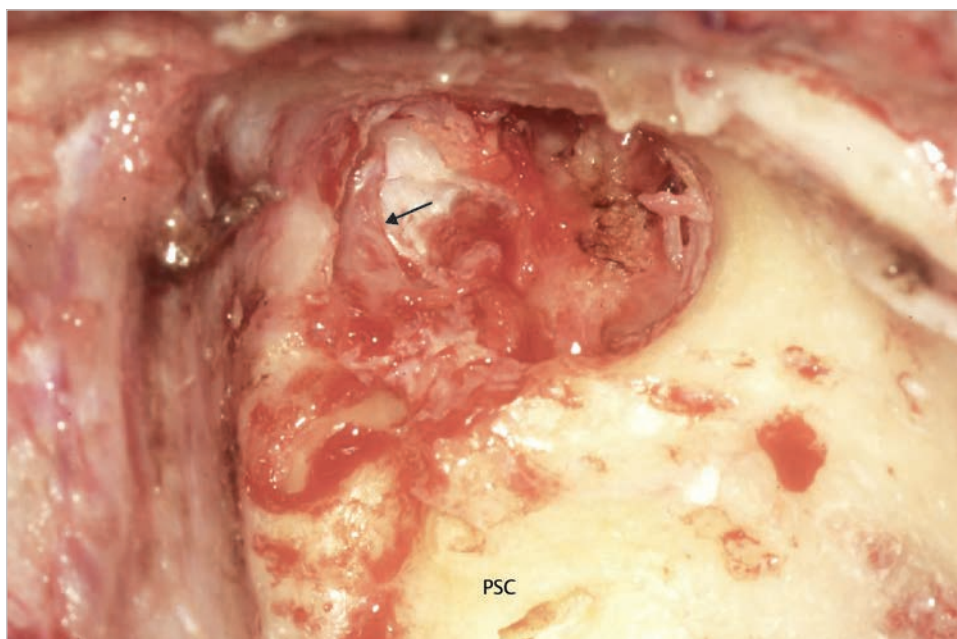


Fig. 14.201 The matrix infiltrating the area of the lateral semicircular canal is removed. The facial nerve exposed under the matrix is seen (*arrow*). PSC, posterior semicircular canal.

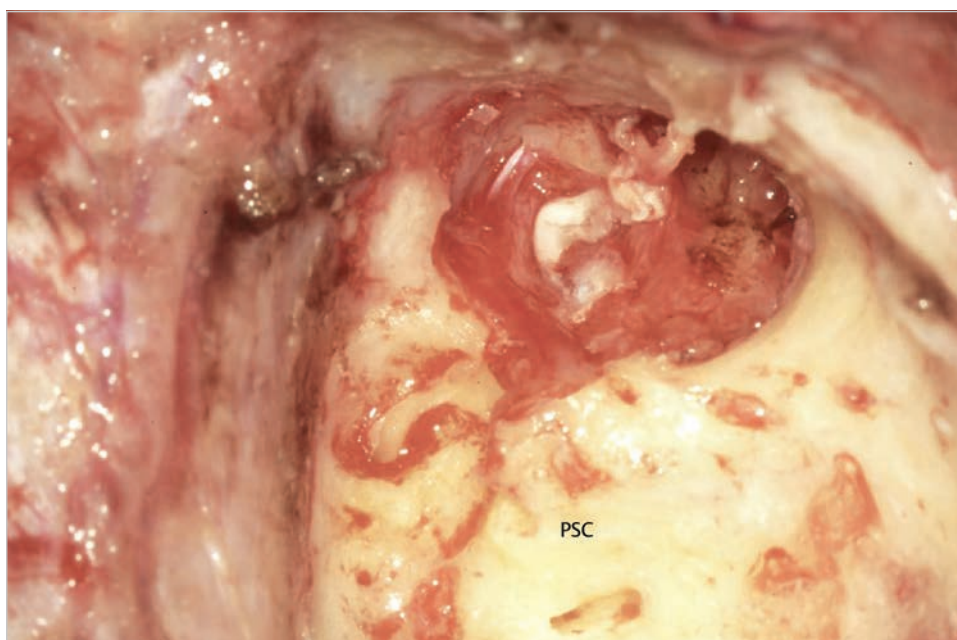


Fig. 14.202 The cholesteatoma eroding the apical turn of the cochlea is seen. PSC, posterior semicircular canal.

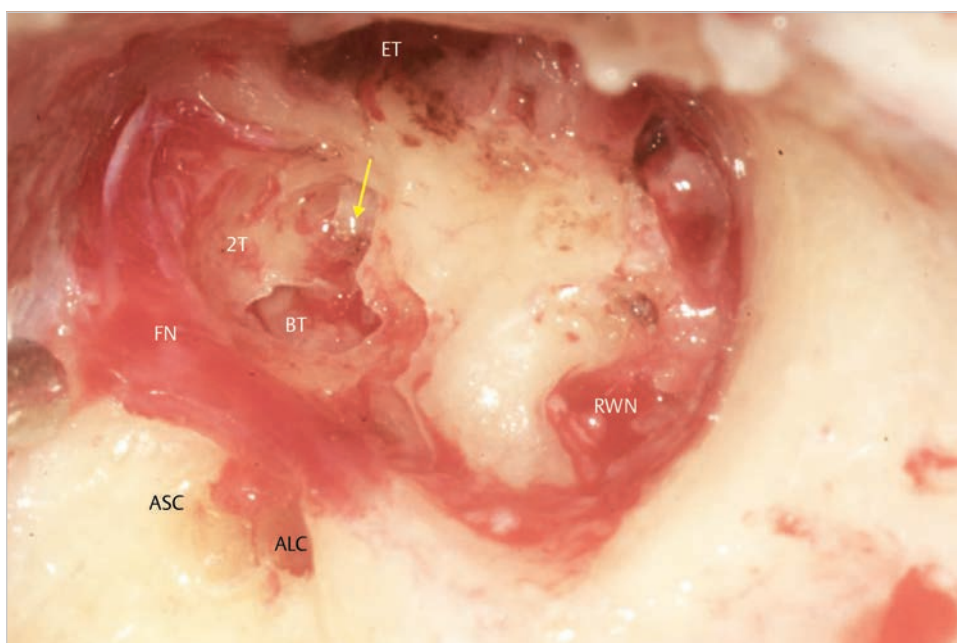


Fig. 14.203 The matrix is removed from the cochlea. The second and the basal turns are seen superiorly to the modiolus (*arrow*). ALC, ampulla of lateral semicircular canal; ASC, ampulla of superior semicircular canal; BT, basal turn of cochlea; ET, eustachian tube; FN, facial nerve; RWN, round window niche; 2T, second turn of cochlea.

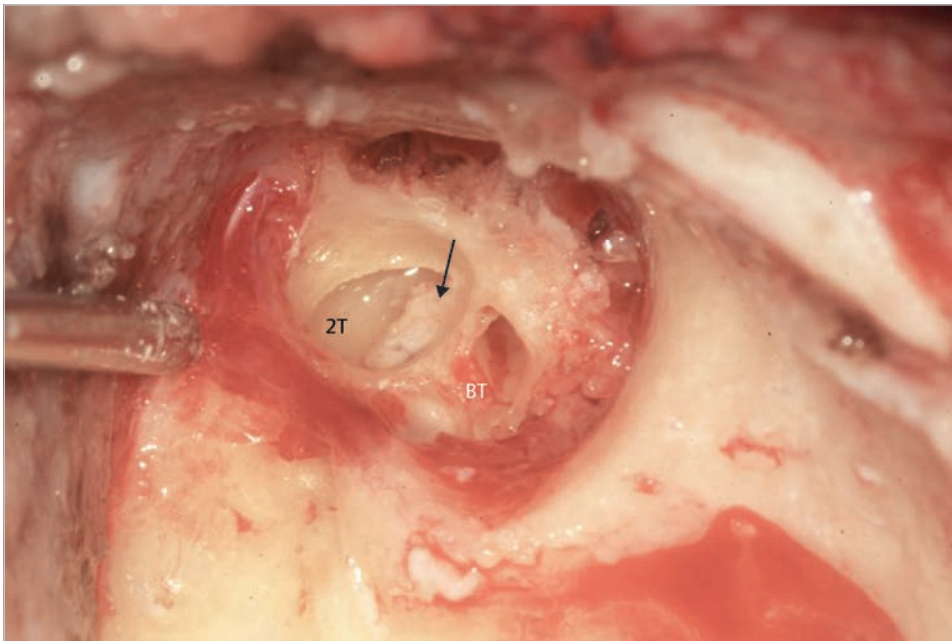


Fig. 14.204 Further drilling of the modiolus resulted in leak of cerebrospinal fluid. The cochlear nerve is seen (arrow). BT, basal turn of cochlea; CN, cochlear nerve; 2T, second turn of cochlea.

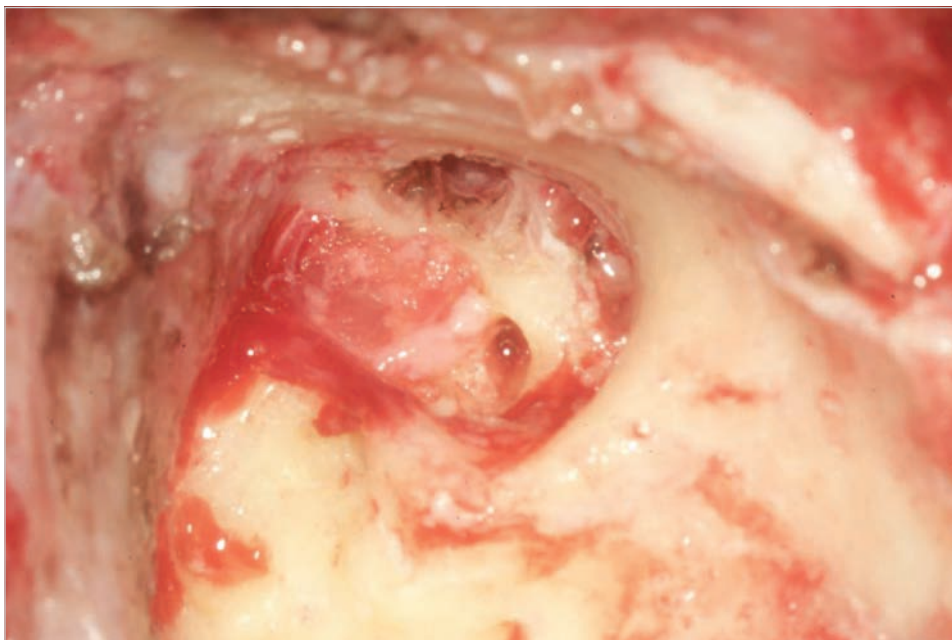


Fig. 14.205 A small piece of temporalis muscle is pushed into the modiolus to seal the internal auditory canal.

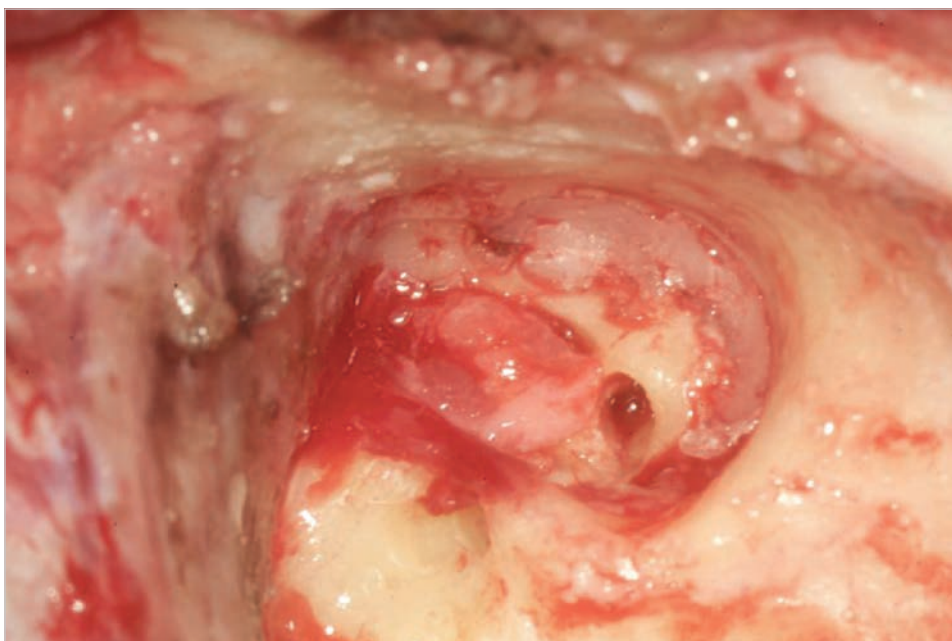


Fig. 14.206 The eustachian tube and hypotympanic cells are closed with bone wax.

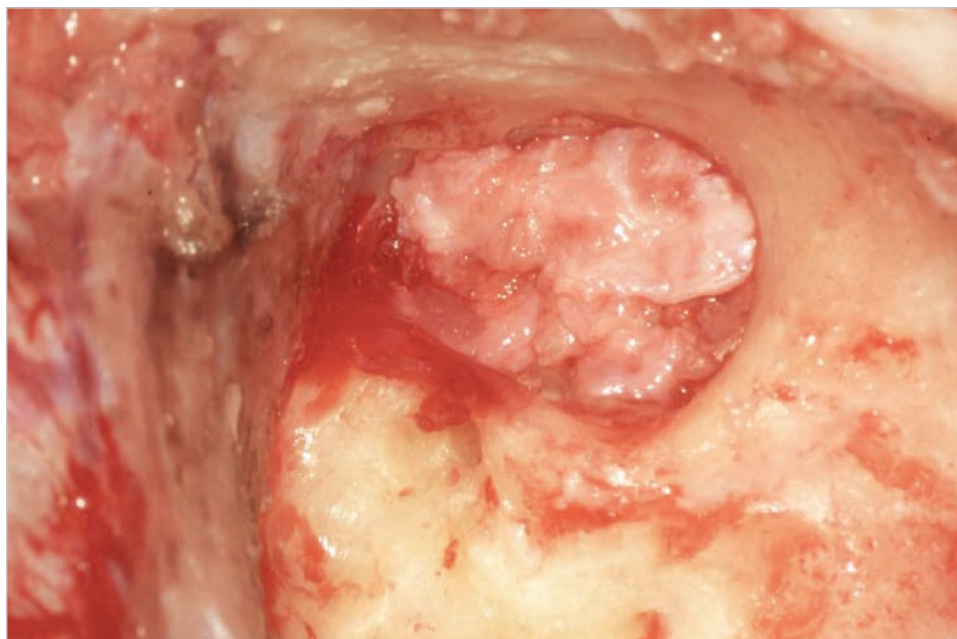


Fig. 14.207 The medial wall of the mesotympanum is packed with pieces of periosteum.

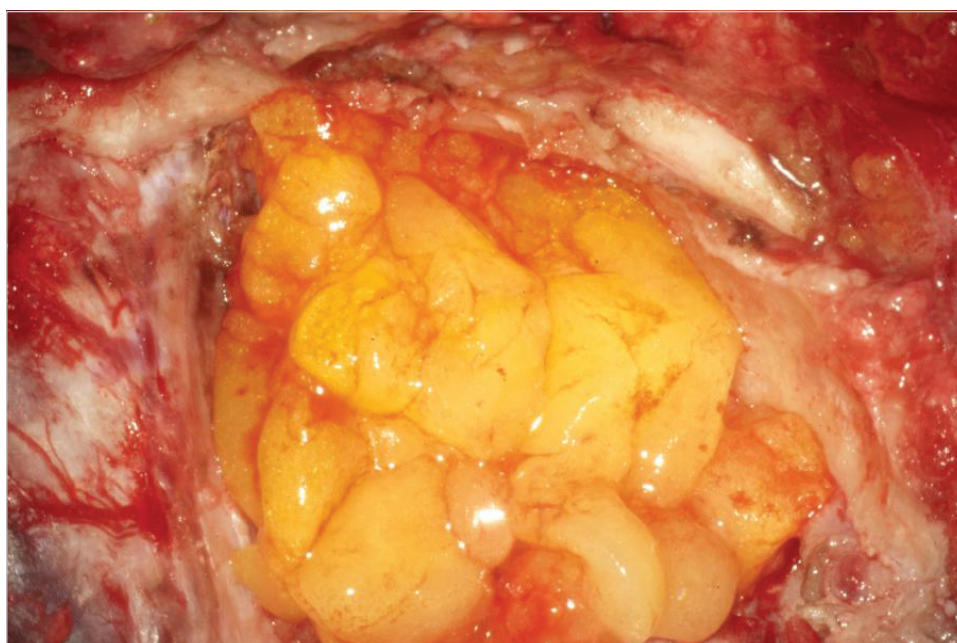


Fig. 14.208 The cavity is packed with abdominal fat.

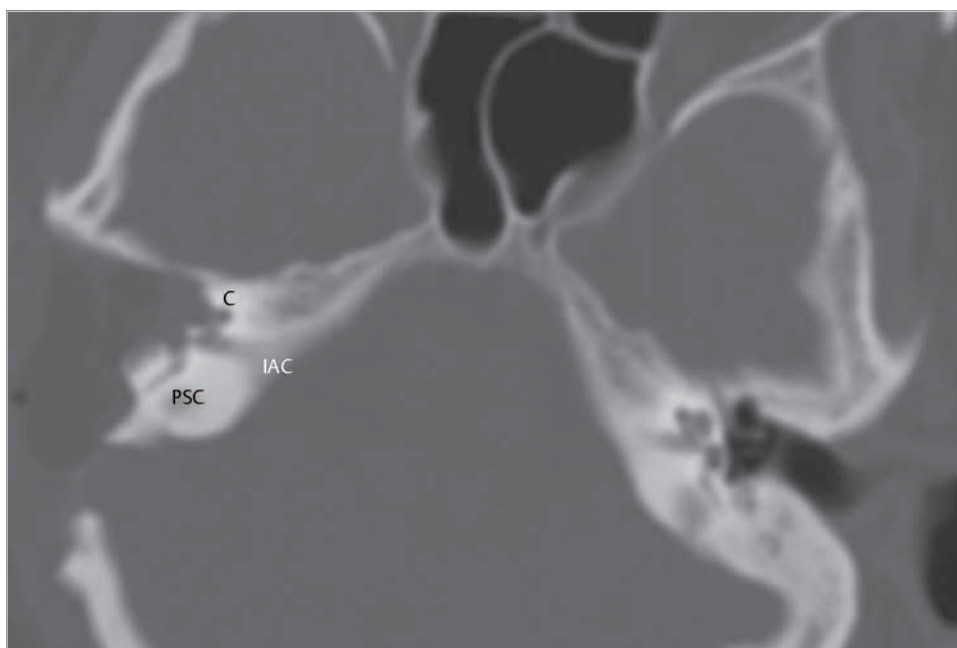


Fig. 14.209 The postoperative CT shows partial removal of both cochlea and the vestibule. C, cochlea; IAC, internal auditory canal; PSC, posterior semicircular canal.

Case 14.9 (Left Ear)

See ▶ Fig. 14.210, ▶ Fig. 14.211, ▶ Fig. 14.212, ▶ Fig. 14.213, ▶ Fig. 14.214, ▶ Fig. 14.215, ▶ Fig. 14.216, ▶ Fig. 14.217,

▶ Fig. 14.218, ▶ Fig. 14.219, ▶ Fig. 14.220, ▶ Fig. 14.221, ▶ Fig. 14.222, ▶ Fig. 14.223, ▶ Fig. 14.224, ▶ Fig. 14.225, ▶ Fig. 14.226, ▶ Fig. 14.227, ▶ Fig. 14.228, ▶ Fig. 14.229, ▶ Fig. 14.230, ▶ Fig. 14.231.

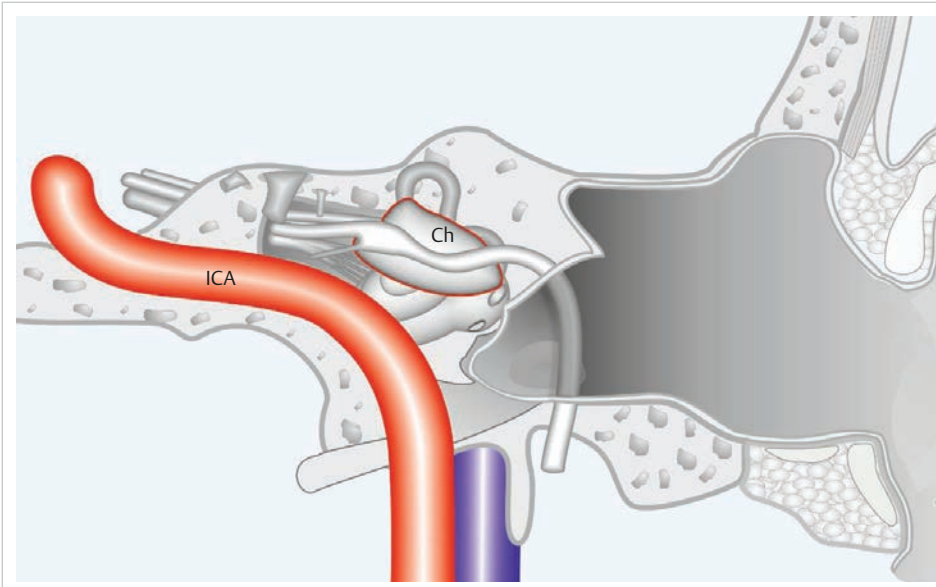


Fig. 14.210 A case of acquired supralabyrinthine cholesteatoma in the radical cavity removed with transotic approach. The cholesteatoma erodes both the cochlea and the vestibule to invaginate into the internal auditory canal. Ch, cholesteatoma; ICA, internal carotid artery.



Fig. 14.211 The 15-year-old adolescent boy suffered from bilateral otorrhea and left hearing disturbance. Cholesteatoma was identified in the left ear elsewhere, and radical mastoidectomy was carried out. A liquorrhea during the surgery resulted in incomplete removal of matrix. The surgery resulted in left dead ear, and the patient was referred to our center for total removal 1 year later. The preoperative MRI of T2-weighted image shows distorted inner ear structure with some high signal intensity around it (arrows).

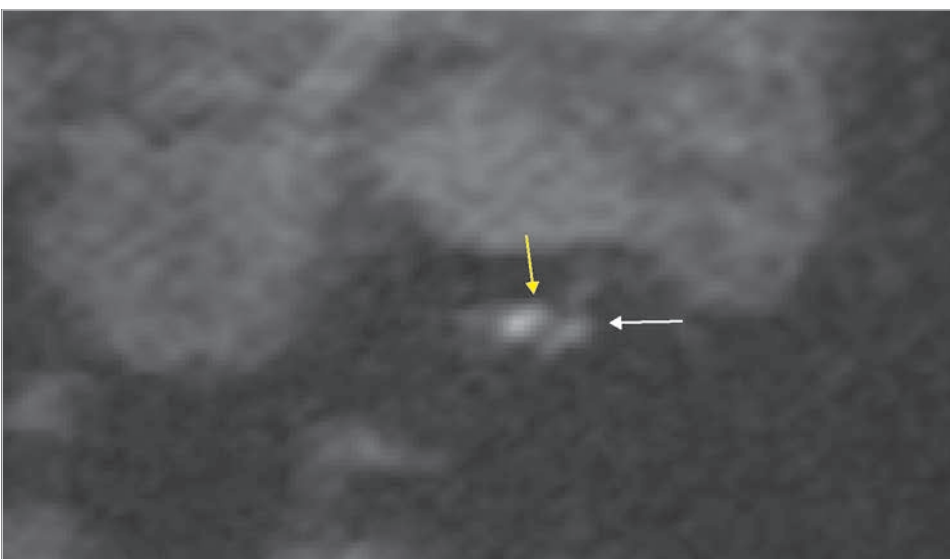


Fig. 14.212 The coronal section of diffusion-weighted MRI demonstrated high signal intensity corresponding to presence of residual cholesteatoma. High signals seem to be located in the fundus of the internal auditory canal (yellow arrow), and the other signal in the inner ear located laterally to the internal auditory canal (white arrow).



Fig. 14.213 After removing the skin covering the cavity completely, the cavity is rounded, and the facial nerve is skeletonized. The semicircular canals are partially removed to gain access to the cholesteatoma eroding the medial wall of the attic. ET, eustachian tube; FN, facial nerve.

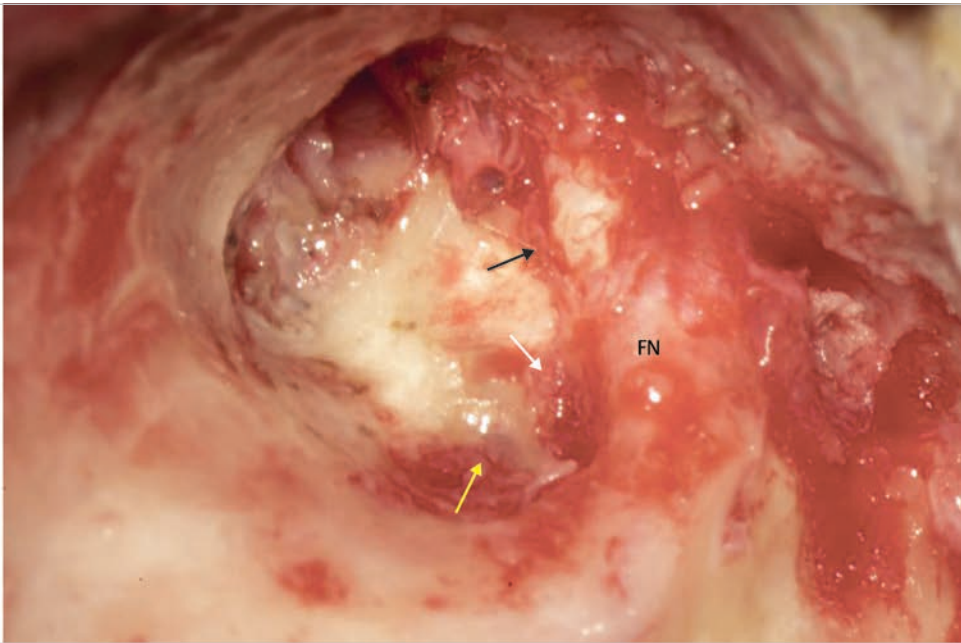
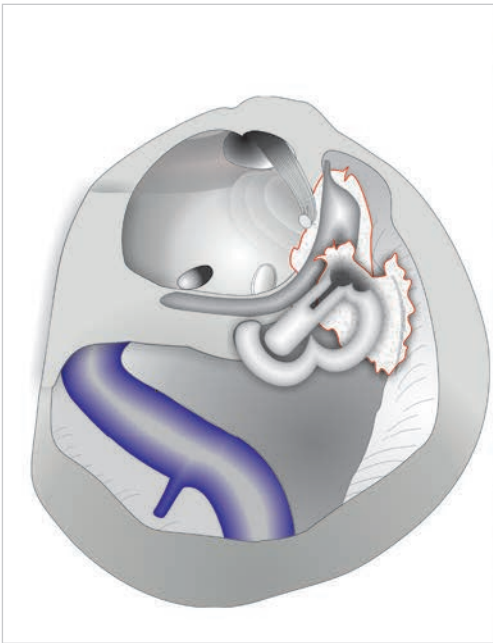


Fig. 14.214 The medial wall of the tympanic cavity is partially drilled. The oval (*white arrow*) and the round (*yellow arrow*) windows are identified. The cholesteatoma is seen beneath the facial nerve (*black arrow*). FN, facial nerve.

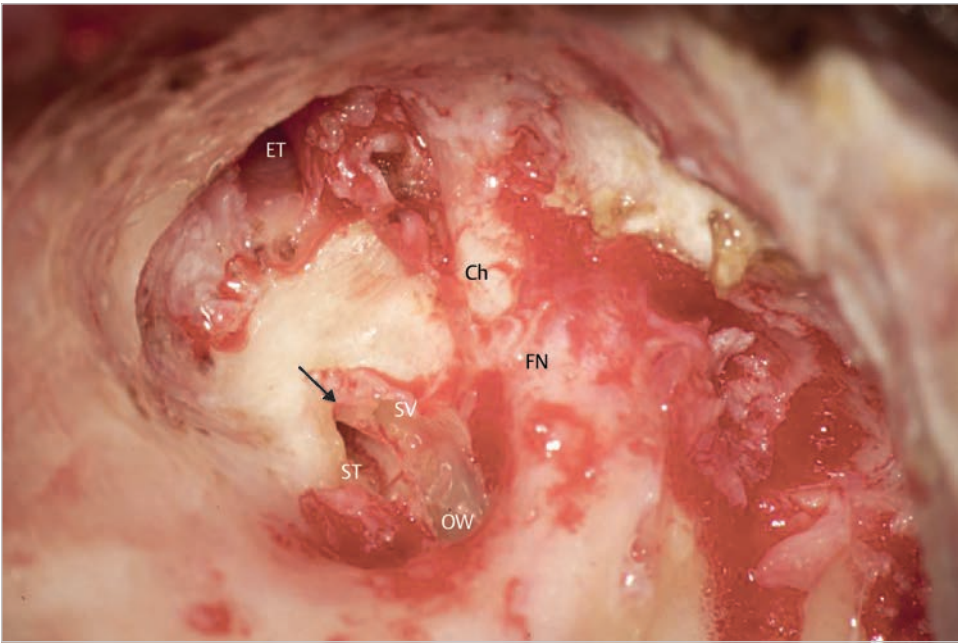


Fig. 14.215 The medial wall of the cochlea is partially drilled to open the basal turn of the cochlea. Note that the oval window and the vestibule correspond to the scala vestibuli located superiorly to the spiral lamina (*arrow*), and the round window corresponds to the scala tympani located inferiorly to the lamina. Ch, cholesteatoma; ET, eustachian tube; FN, facial nerve; OW, oval window; ST, scala tympani; SV, scala vestibuli.

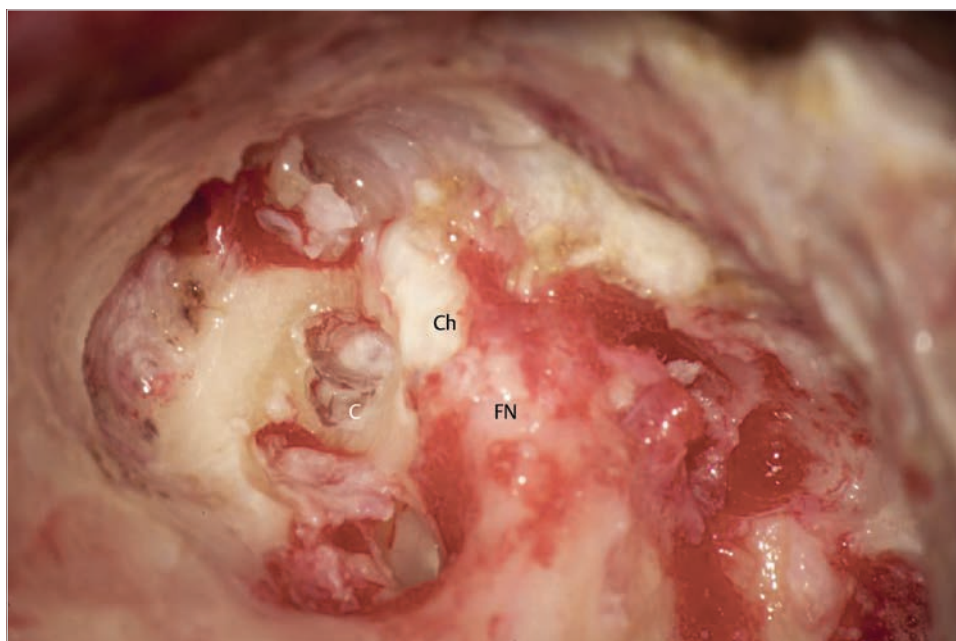


Fig. 14.216 Drilling of the cochlea is advanced superiorly to reach the area of the apical turn. The cholesteatoma located between the facial nerve and the cochlea is seen. C, cochlea; Ch, cholesteatoma; FN, facial nerve.

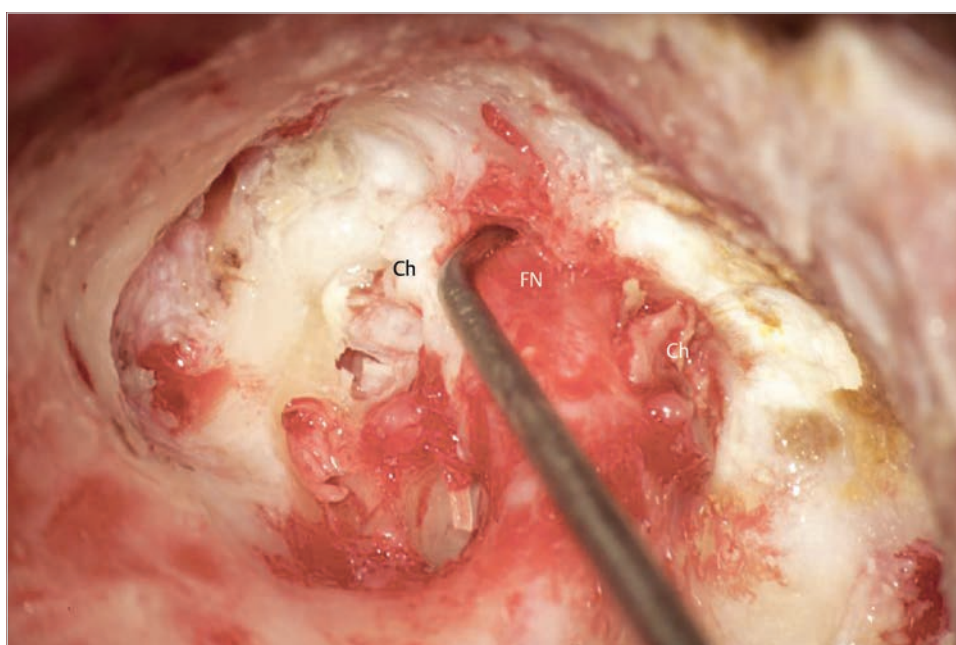


Fig. 14.217 Before starting dissection of cholesteatoma beneath the facial nerve, the nerve in this area is exposed and freed from the bone. The procedure permits gentle mobilization of the nerve and improves visualization and gives more room for dissection without stretching the nerve. For that sake, the bone covering the greater superficial petrosal nerve pointed by the instrument is removed. Ch, cholesteatoma; FN, facial nerve.

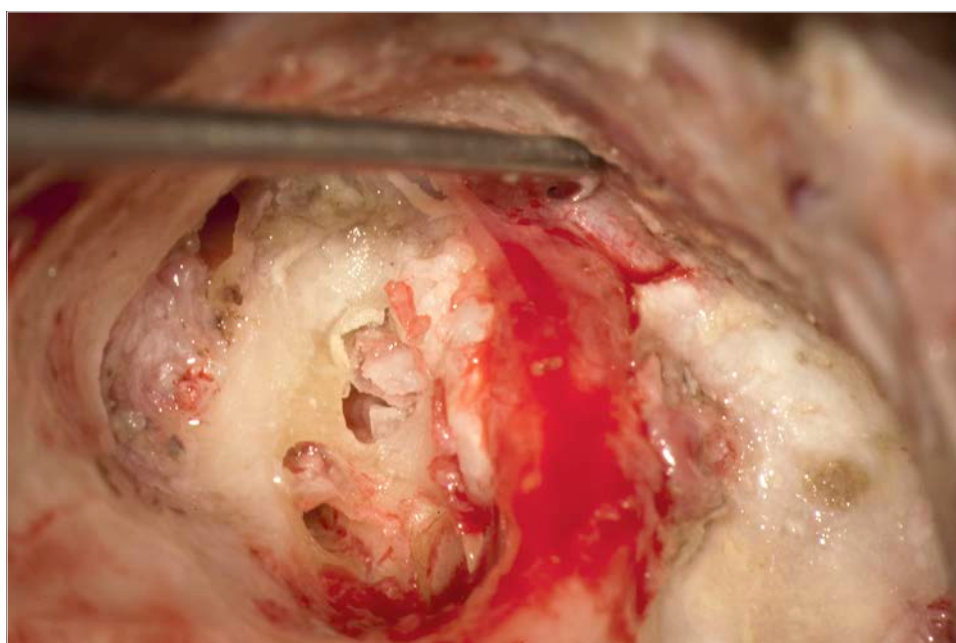


Fig. 14.218 The geniculate ganglion and the greater superficial petrosal nerve (yellow arrow) are followed anteriorly and totally exposed. The instrument is pushing the middle fossa dura (white arrow). At this level, the superior face of the ganglion and the great superficial petrosal nerve may touch to the middle fossa dura. It is very important to preserve vasculature of the greater superficial petrosal nerve that is important for facial nerve function. Ch, cholesteatoma; FN, facial nerve.

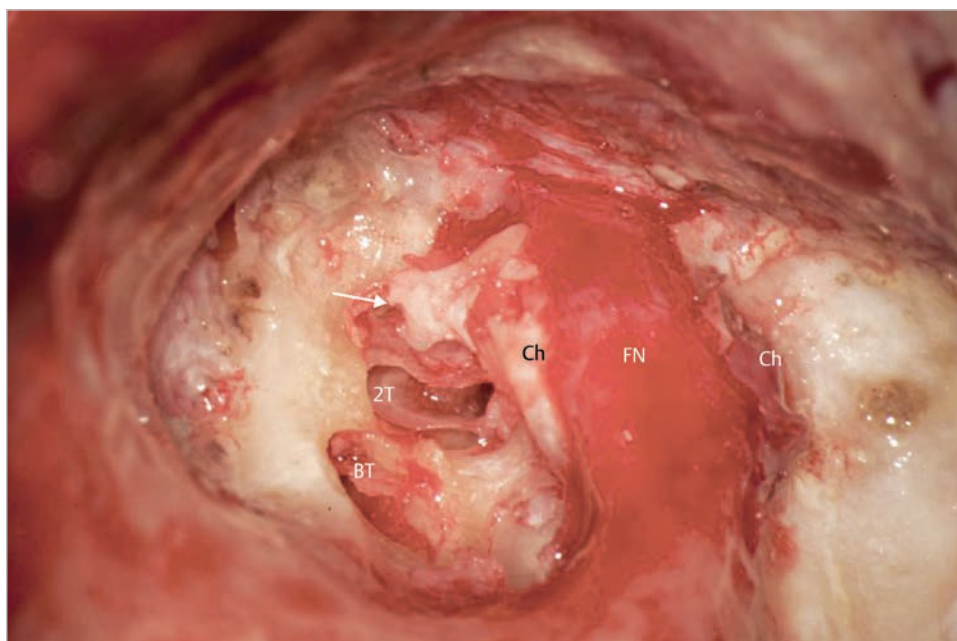


Fig. 14.219 Cholesteatoma infiltrating the apical turn of the cochlea is seen (*arrow*). The facial nerve is elevated. 2T, second turn of cochlea; BT, basal turn of cochlea; Ch, cholesteatoma; FN, facial nerve.

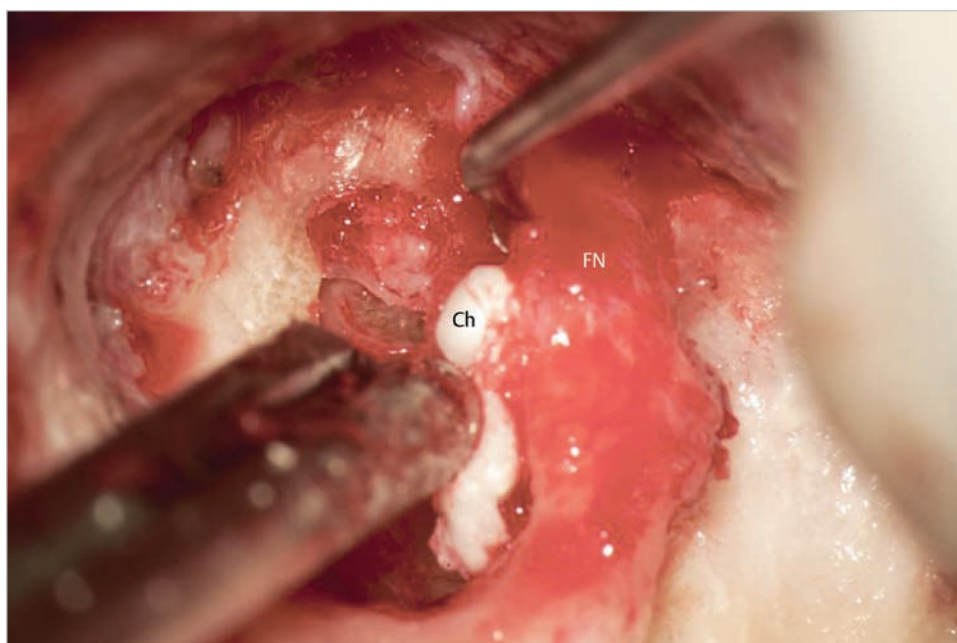


Fig. 14.220 The cholesteatoma is dissected from the area of the labyrinthine segment passing under the geniculate ganglion. Ch, cholesteatoma; FN, facial nerve.

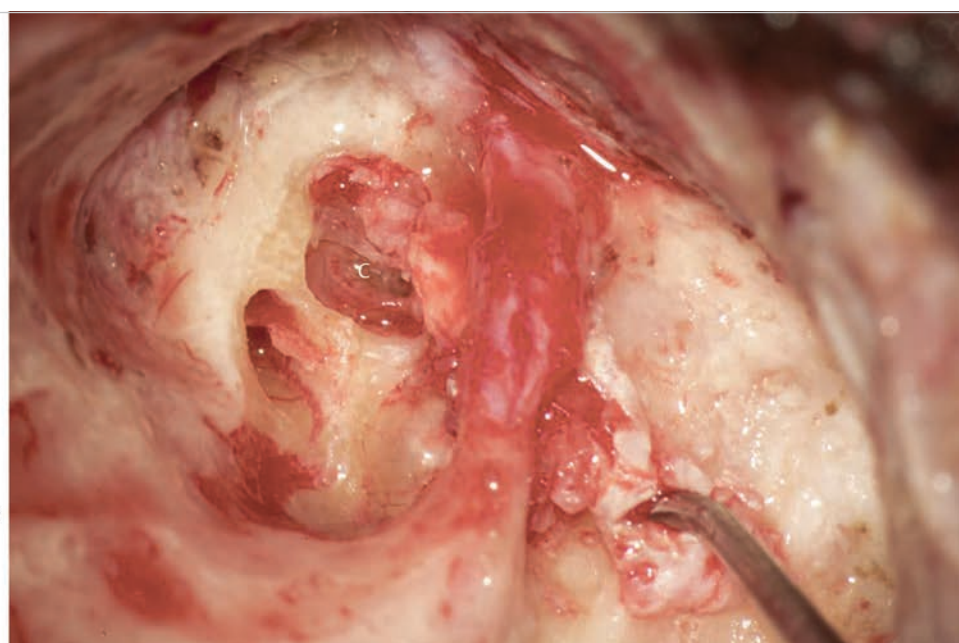
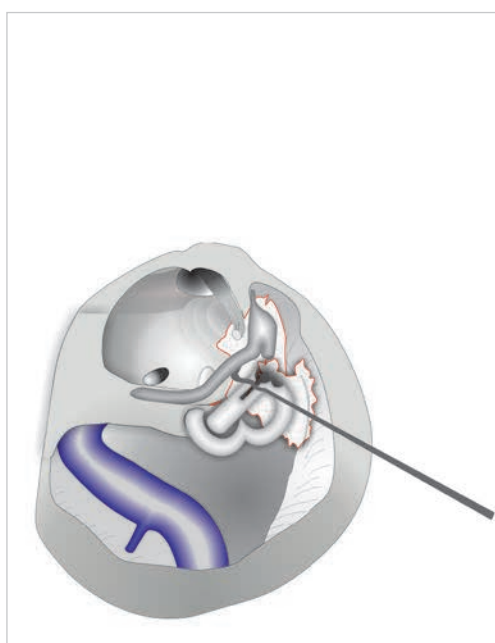


Fig. 14.221 Cholesteatoma is detached from the medial face of the fallopian canal and pulled out with a small dissector. C, cochlea.

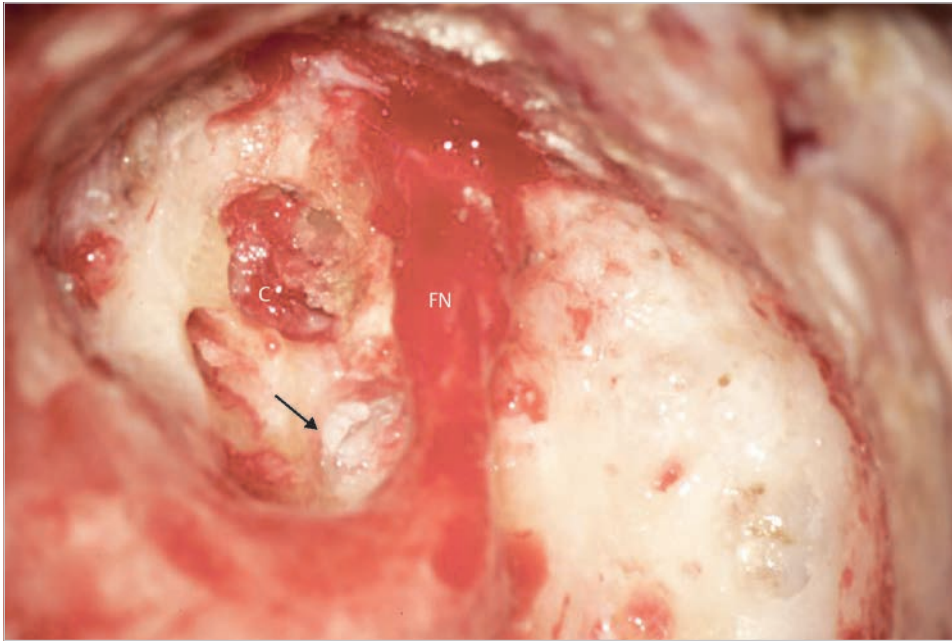


Fig. 14.222 Debulking of the cholesteatoma occupying the vestibule revealed cholesteatoma matrix infiltrating the internal auditory canal (arrow). C, cochlea; FN, facial nerve.

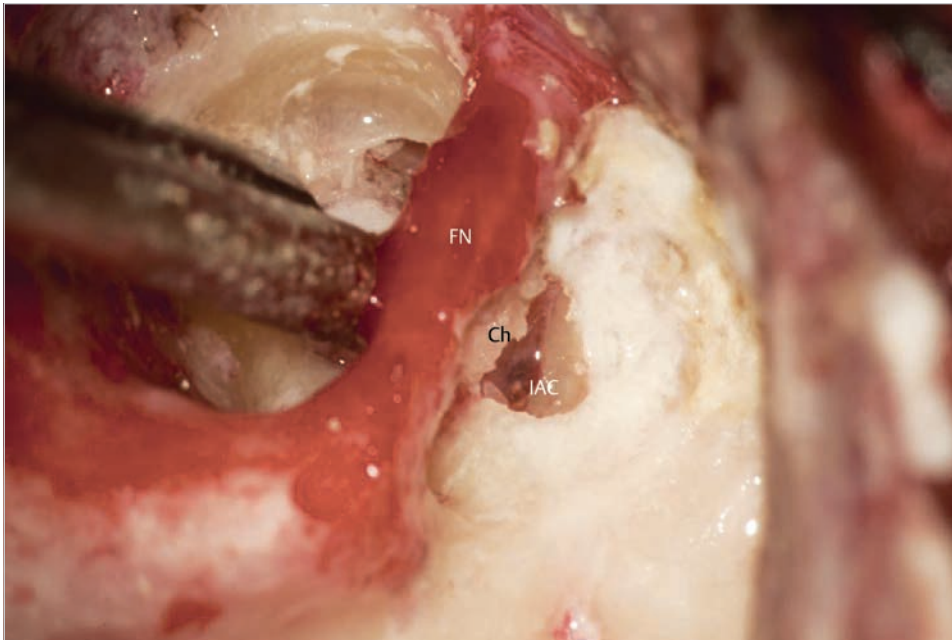


Fig. 14.223 To remove cholesteatoma infiltrating the fundus of the internal auditory canal, the lateral part of the internal auditory canal is opened from its posterosuperior face taking care not to damage the labyrinthine segment of the facial nerve. Ch, cholesteatoma; FN, facial nerve; IAC, internal auditory canal.

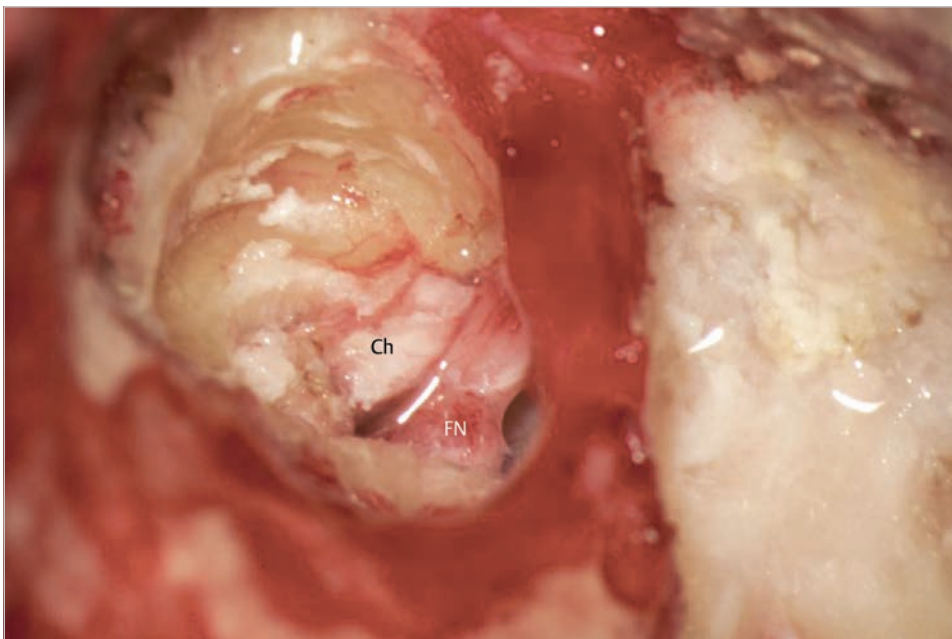


Fig. 14.224 The final piece of cholesteatoma located anteriorly to the facial nerve in the internal auditory canal is seen. Ch, cholesteatoma; FN, facial nerve (intracanalicular segment).

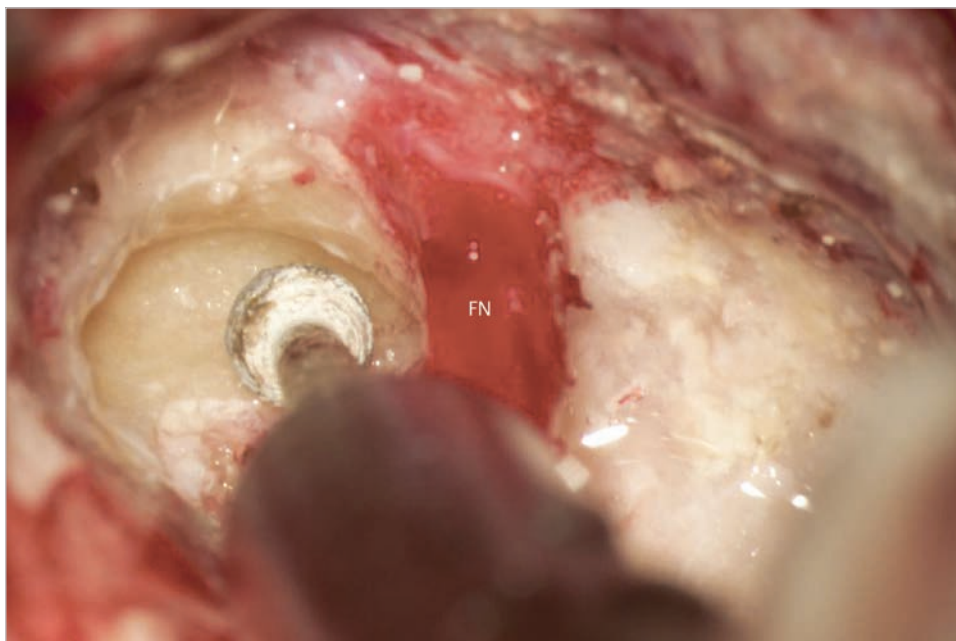


Fig. 14.225 An access to the cholesteatoma is widened by removing the bone anteriorly to the internal auditory canal. In this particular drilling, great care should be taken not to let the burr head slip into the internal auditory canal. The largest possible diamond burr should be used, and it should not be pushed toward the internal auditory canal. FN, facial nerve.

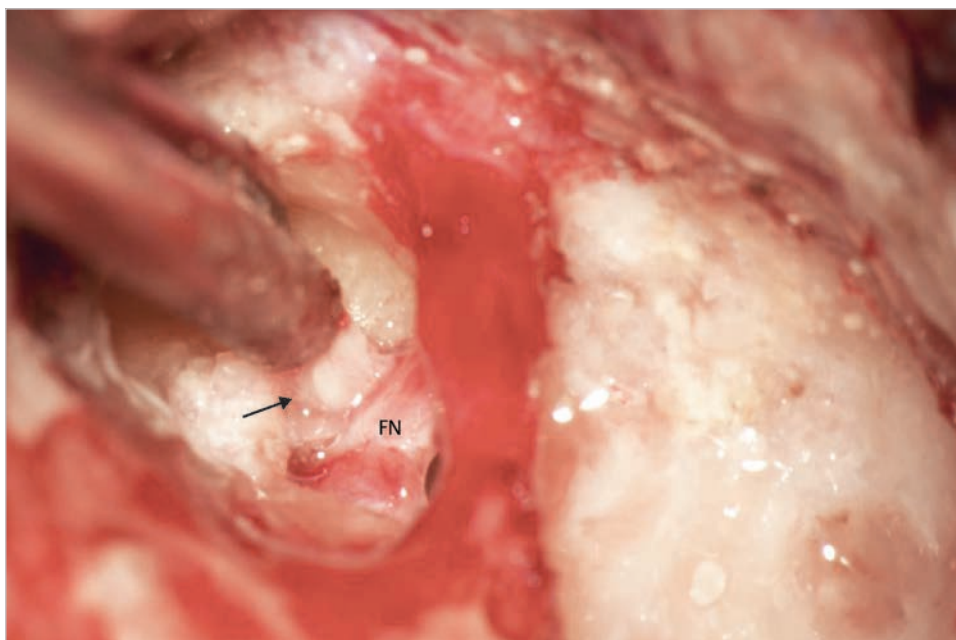


Fig. 14.226 The final piece of cholesteatoma located anteriorly to the facial nerve is visualized (*arrow*). FN, facial nerve (intracanalicular segment).



Fig. 14.227 The cholesteatoma is completely removed from the internal auditory canal. FN, facial nerve; IAC, internal auditory canal.

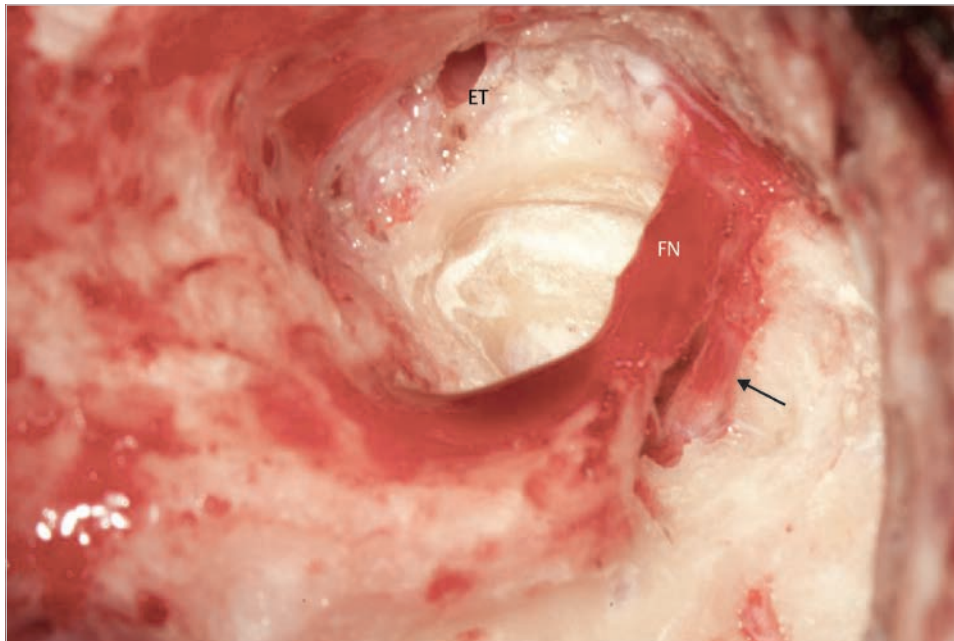


Fig. 14.228 Complete removal of cholesteatoma is achieved. The intracanalicular and the labyrinthine segment of the nerve can be seen clearly (*arrow*). ET, eustachian tube; FN, facial nerve (tympanic segment).

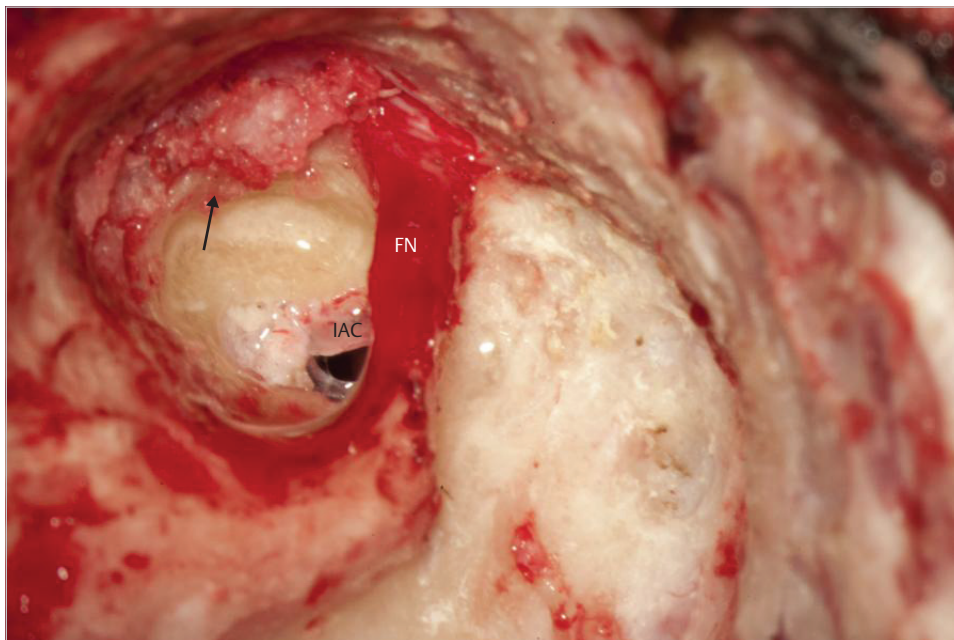


Fig. 14.229 Pieces of periosteum are used to close the eustachian tube (*arrow*) to prevent postoperative rhino liquorrhea. FN, facial nerve; IAC, internal auditory canal.

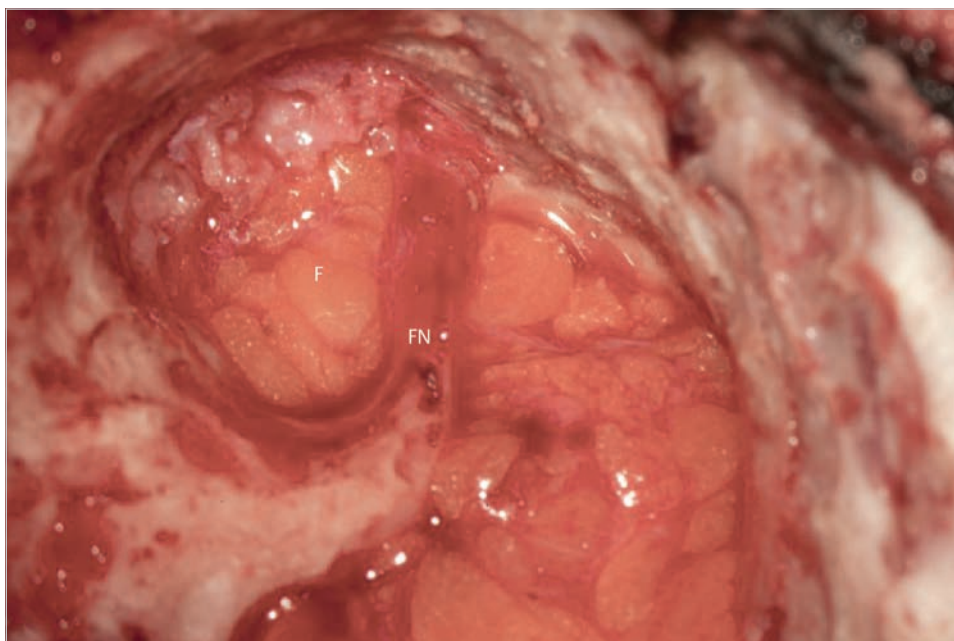


Fig. 14.230 The internal auditory canal is packed with small pieces of abdominal fat. The cavity is obliterated with larger pieces. F, abdominal fat; FN, facial nerve.

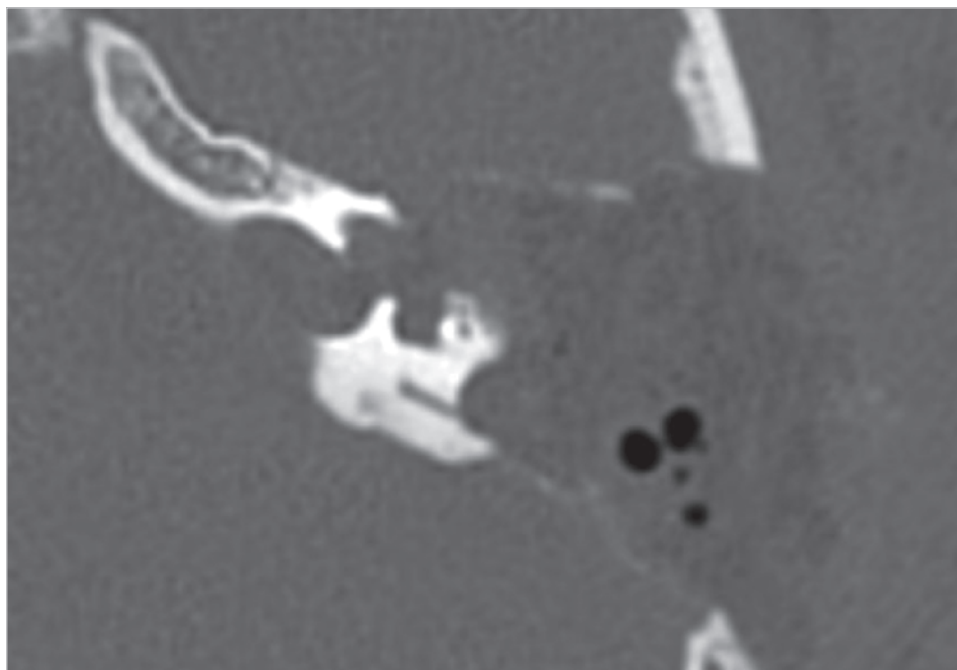


Fig. 14.231 The postoperative CT demonstrates removal of lateral part of the labyrinth cochlea.

Case 14.10 (Right Ear)

See ▶ Fig. 14.232, ▶ Fig. 14.233, ▶ Fig. 14.234, ▶ Fig. 14.235, ▶ Fig. 14.236, ▶ Fig. 14.237, ▶ Fig. 14.238, ▶ Fig. 14.239, ▶ Fig. 14.240, ▶ Fig. 14.241, ▶ Fig. 14.242, ▶ Fig. 14.243, ▶ Fig. 14.244, ▶ Fig. 14.245, ▶ Fig. 14.246, ▶ Fig. 14.247, ▶ Fig. 14.248, ▶ Fig. 14.249, ▶ Fig. 14.250, ▶ Fig. 14.251, ▶ Fig. 14.252, ▶ Fig. 14.253, ▶ Fig. 14.254, ▶ Fig. 14.255, ▶ Fig. 14.256, ▶ Fig. 14.257, ▶ Fig. 14.258, ▶ Fig. 14.259.

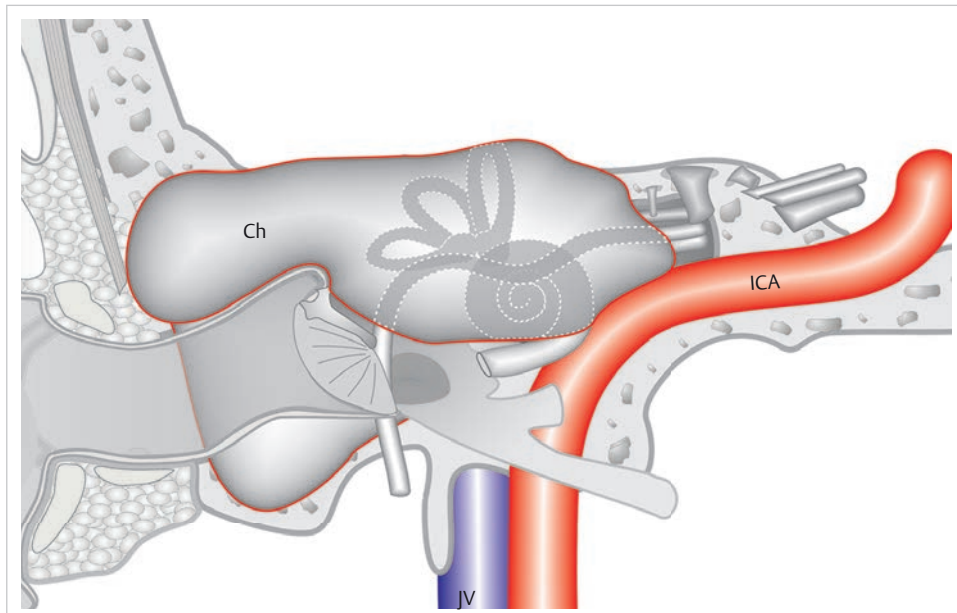


Fig. 14.232 A case of acquired supralabyrinthine cholesteatoma with erosion of both the cochlea and the posterior labyrinth with a small extension anteriorly to the internal auditory canal treated with modified transcochlear approach. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

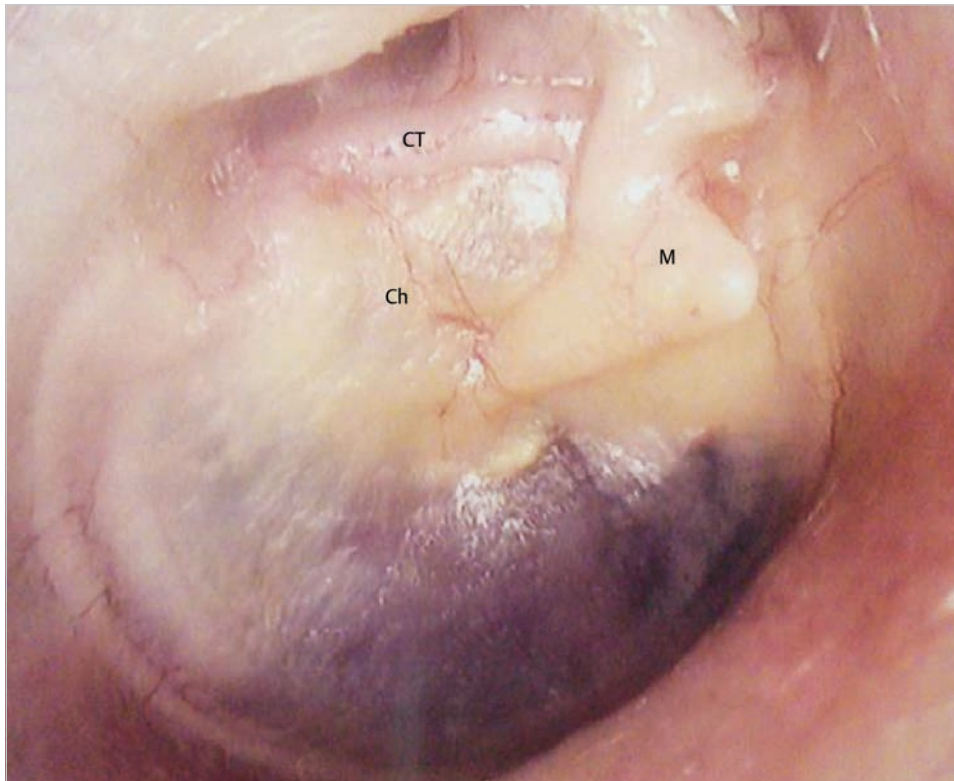


Fig. 14.233 This 60-year-old man visited our office with anacusis and facial nerve palsy. The otoscopy shows a dry clean retraction in the attic. Presence of whitish matter behind the tympanic membrane is the only clue for the presence of cholesteatoma. Ch, cholesteatoma; CT, chorda tympanica nerve; M, malleus.

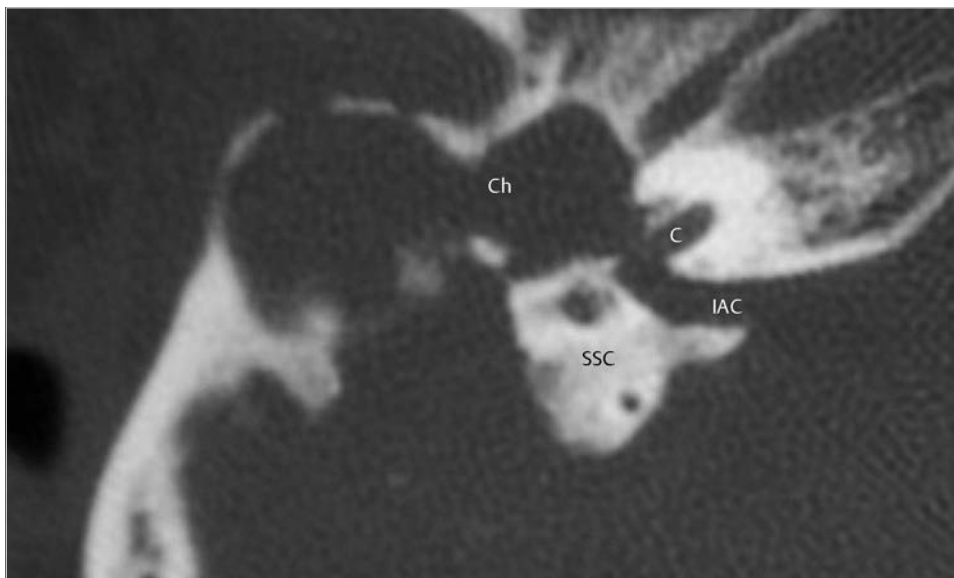


Fig. 14.234 The axial CT shows erosion of the cochlea with involvement of the facial nerve by the cholesteatoma. C, cochlea; Ch, cholesteatoma; IAC, internal auditory canal; SSC, superior semicircular canal.

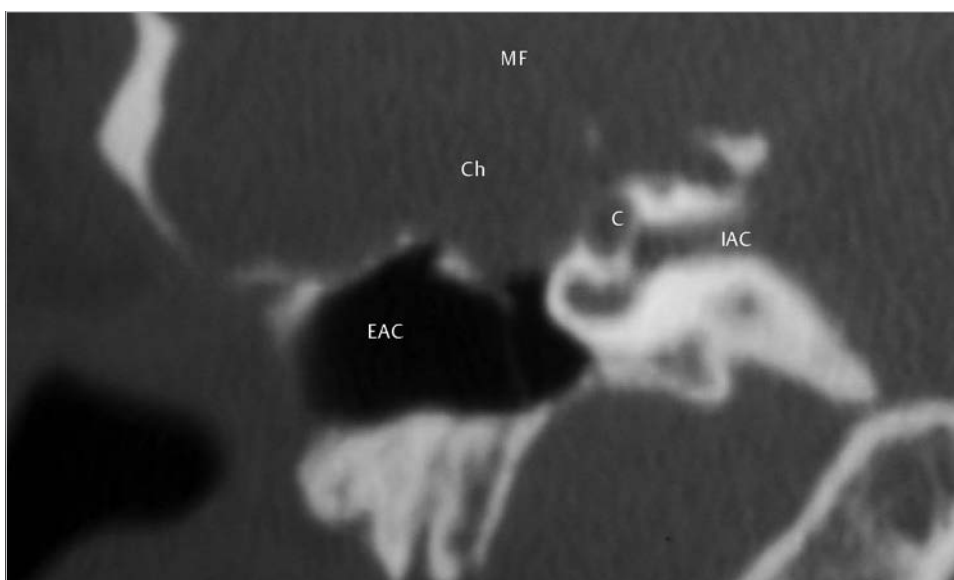


Fig. 14.235 The coronal CT shows severe erosion of the otic capsule and extensive extension of the cholesteatoma medially to the labyrinth. C, cochlea; Ch, cholesteatoma; EAC, external auditory canal; IAC, internal auditory canal; MF, middle fossa.

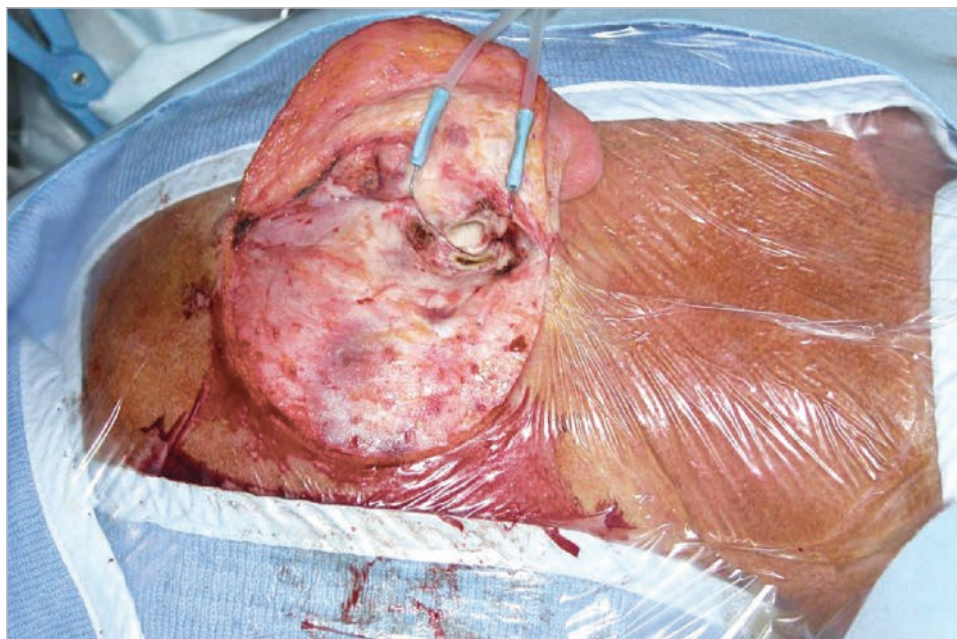


Fig. 14.236 After preparing the operating field in the manner described, a large U-shaped skin incision is made, and the skin flap is dissected anteriorly. To prevent postoperative CSF leak from the wound, it is very important to preserve musculoperiosteal layer intact. The external auditory canal is transected at the level of musculoperiosteal flap. The skin flap together with the auricle is maintained anteriorly with skin hooks.

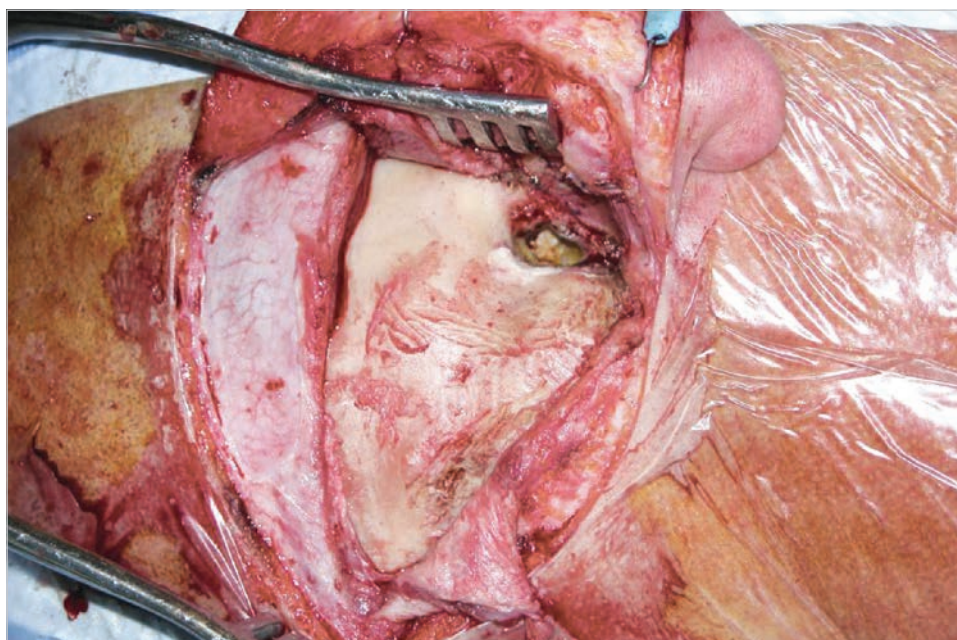


Fig. 14.237 The wound is opened in two layers. Incision in the musculoperiosteal layer should be away from the skin incision to prevent postoperative CSF leak. The external auditory canal should be closed in the beginning of the surgery.

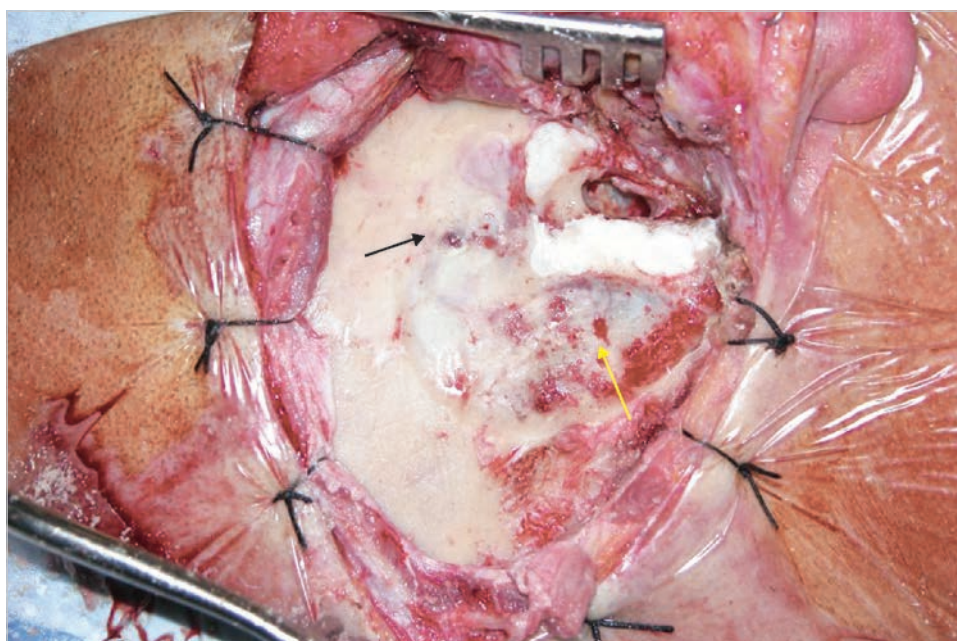


Fig. 14.238 For maximum exposure of the skull, stitches are used to hold the musculoperiosteal layer away from the surgical field instead of skin retractors. Mastoidectomy after identifying the sigmoid sinus posteriorly (yellow arrow) and the middle fossa plate superiorly (black arrow) revealed cholesteatoma filling the mastoid air cells and covering the middle fossa dura.

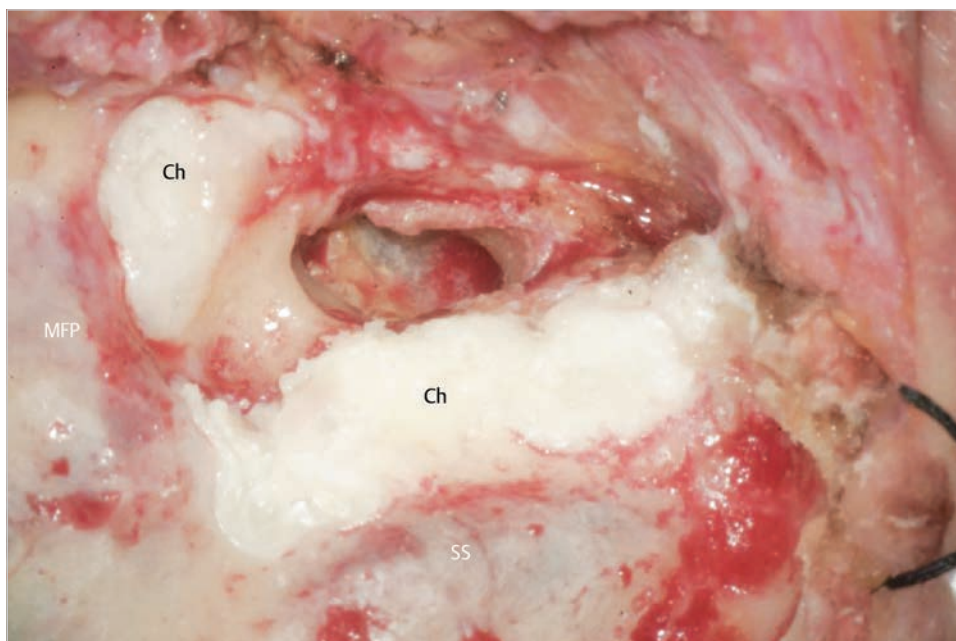


Fig. 14.239 Removal of cortical bone immediately exposed the cholesteatoma filling the middle ear. The cholesteatoma entered from the pars flaccida of the tympanic membrane, with the pars tensa in position. Ch, cholesteatoma; MFP, middle fossa plate; SS, sigmoid sinus.

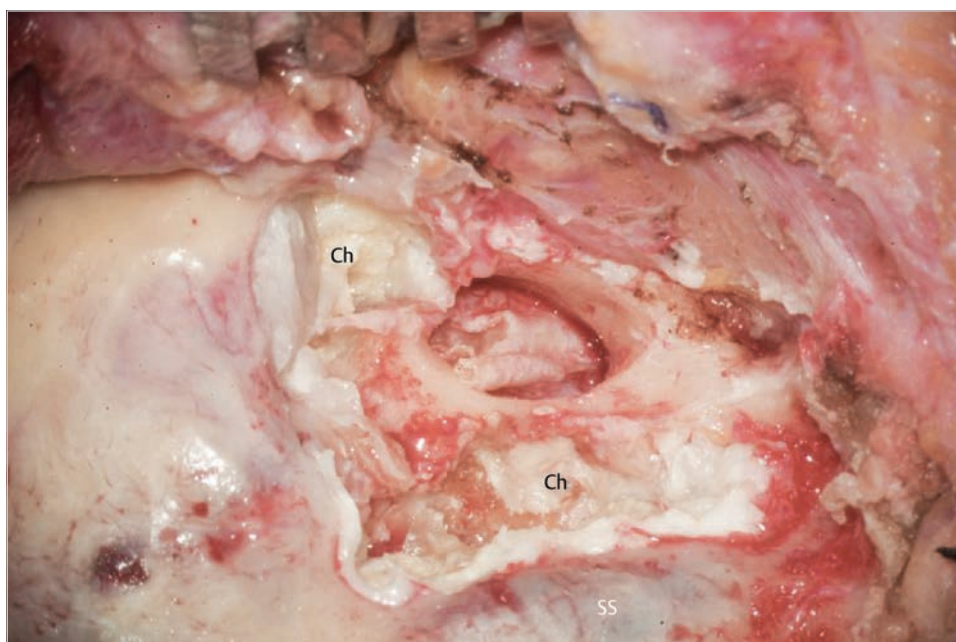


Fig. 14.240 The matrix is opened, and debris is partially evacuated to dissect the matrix. The mastoid and the attic are completely occupied by the cholesteatoma. The meatal skin is detached medially. Ch, cholesteatoma; SS, sigmoid sinus.

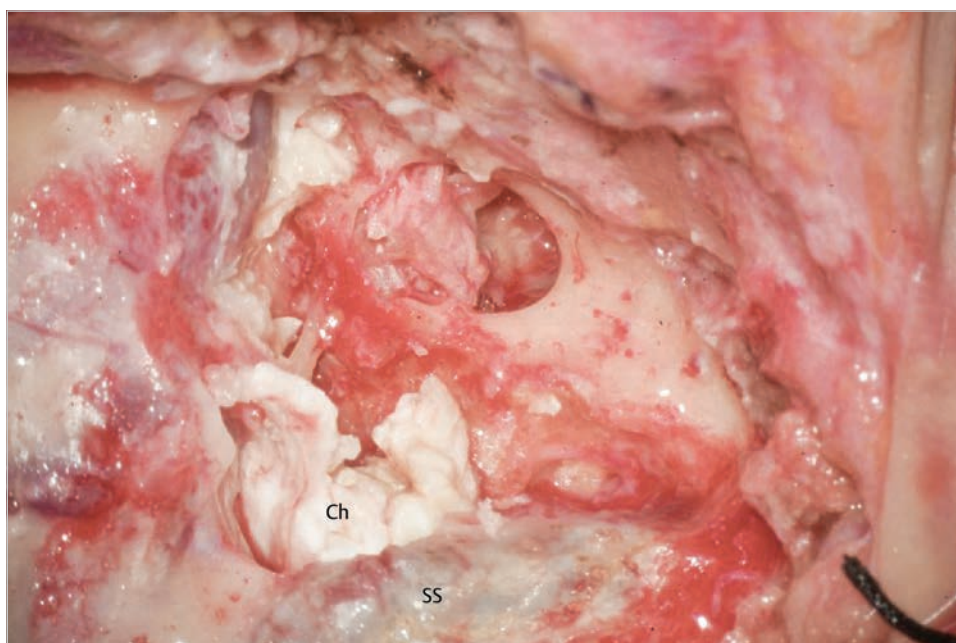


Fig. 14.241 The cholesteatoma widely exposed the middle fossa dura. No cholesteatoma is seen in the hypotympanum. Ch, cholesteatoma; SS, sigmoid sinus.

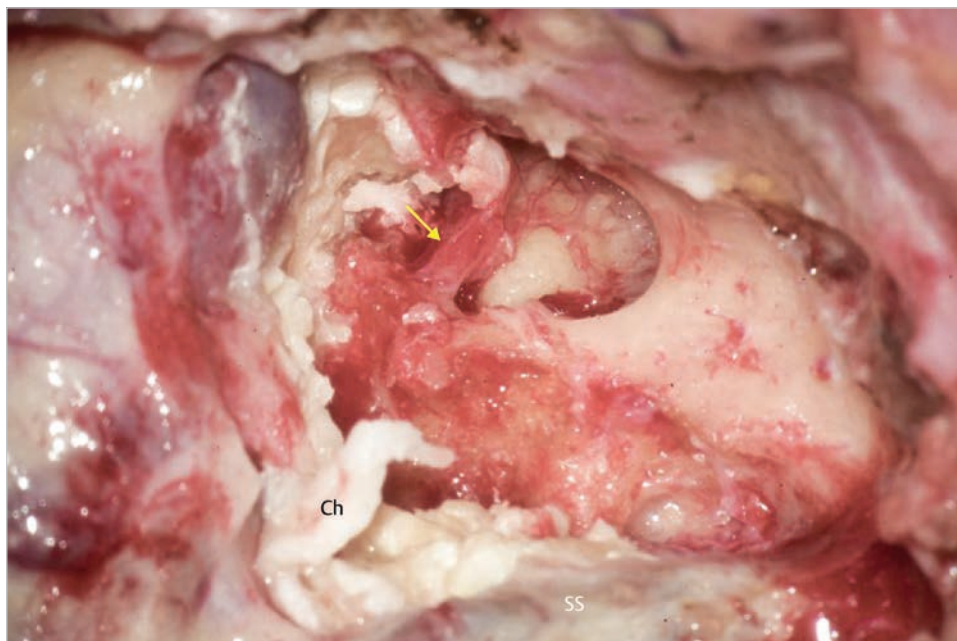


Fig. 14.242 The posterior canal wall is removed, and dissection of the cholesteatoma from the middle fossa dura is further carried out. The tympanomeatal flap is removed. The cholesteatoma heavily eroded the medial wall of the attic, and the superior aspect of the tympanic segment of the facial nerve (*arrow*) is widely exposed. Ch, cholesteatoma; SS, sigmoid sinus.

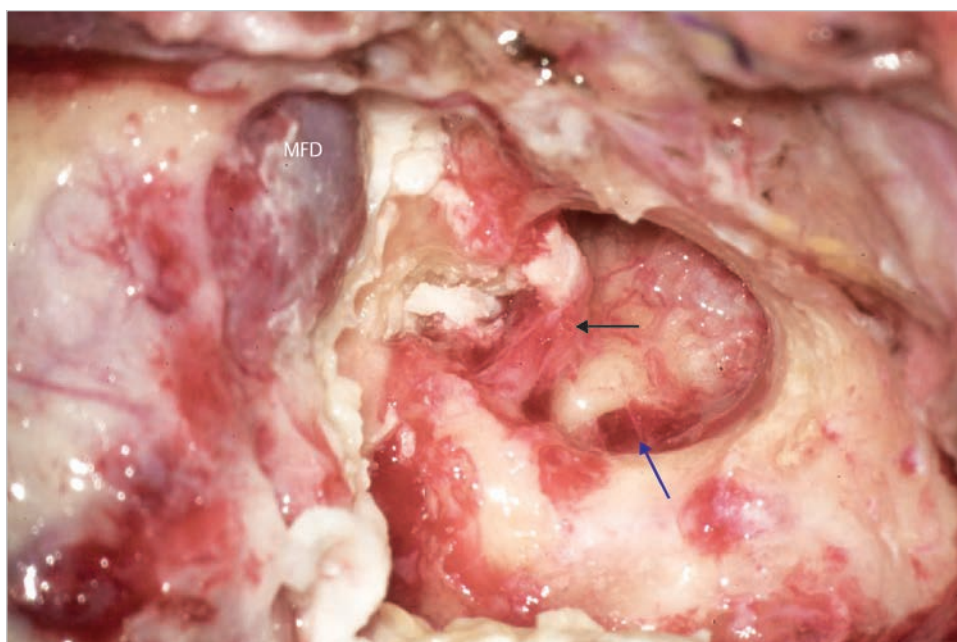


Fig. 14.243 Closer view. The facial nerve courses just superomedially to the cochleariform process (*black arrow*). The round window niche (*blue arrow*) is identified posteroinferiorly to the promontory. MFD, middle fossa dura.

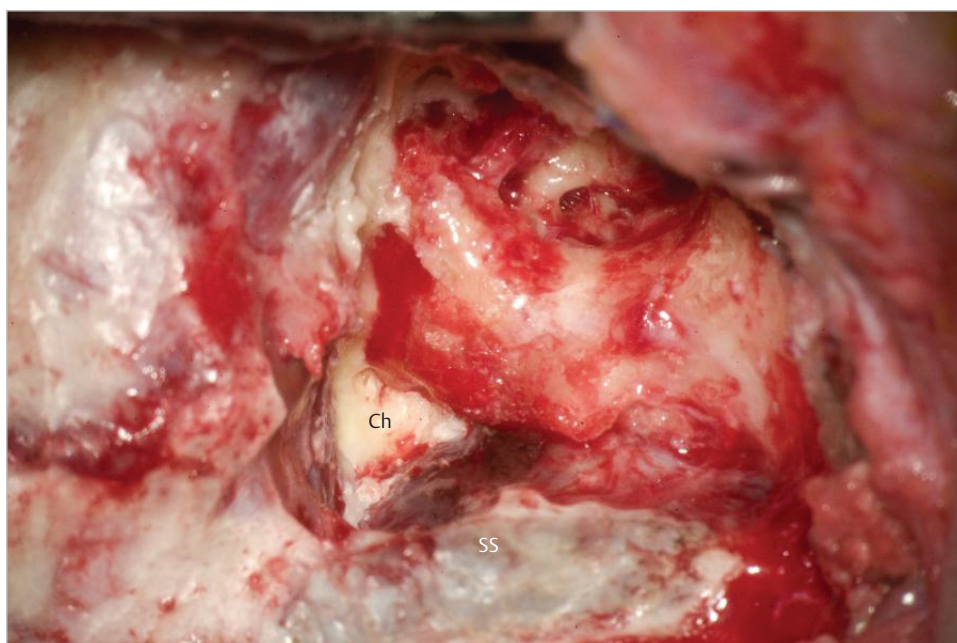


Fig. 14.244 The cholesteatoma filling the sinodural angle is shown. Bone forming the tegmen is completely disappeared, and the posterior fossa dura is also exposed. The medial end of the cholesteatoma surpasses the otic capsule. Ch, cholesteatoma; SS, sigmoid sinus.

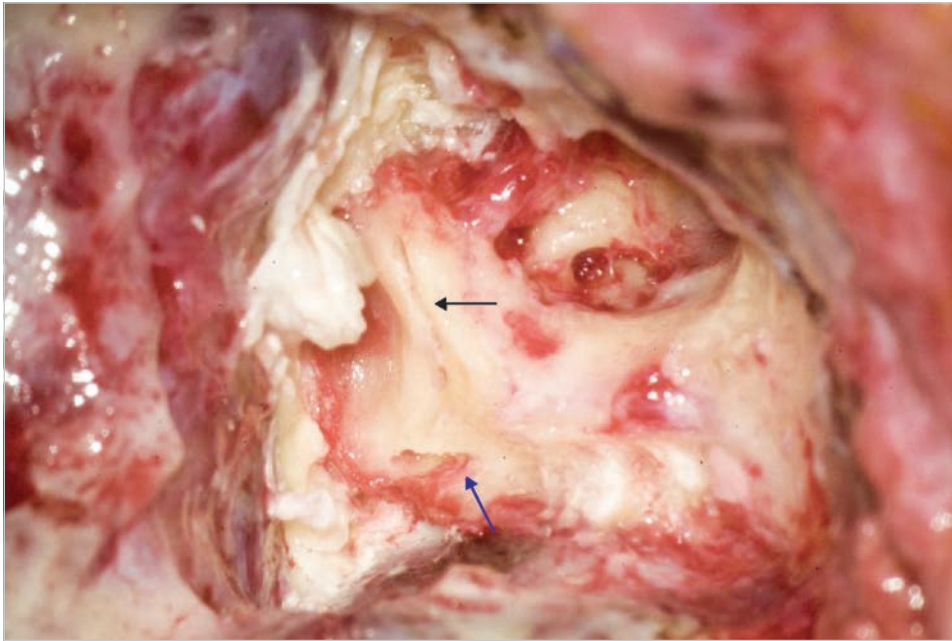


Fig. 14.245 To manage cholesteatoma medially to the labyrinth, a labyrinthectomy is indicated. The lateral (*black arrow*) and the posterior (*blue arrow*) semicircular canals are seen. Note that the cholesteatoma matrix totally encompasses the labyrinth.

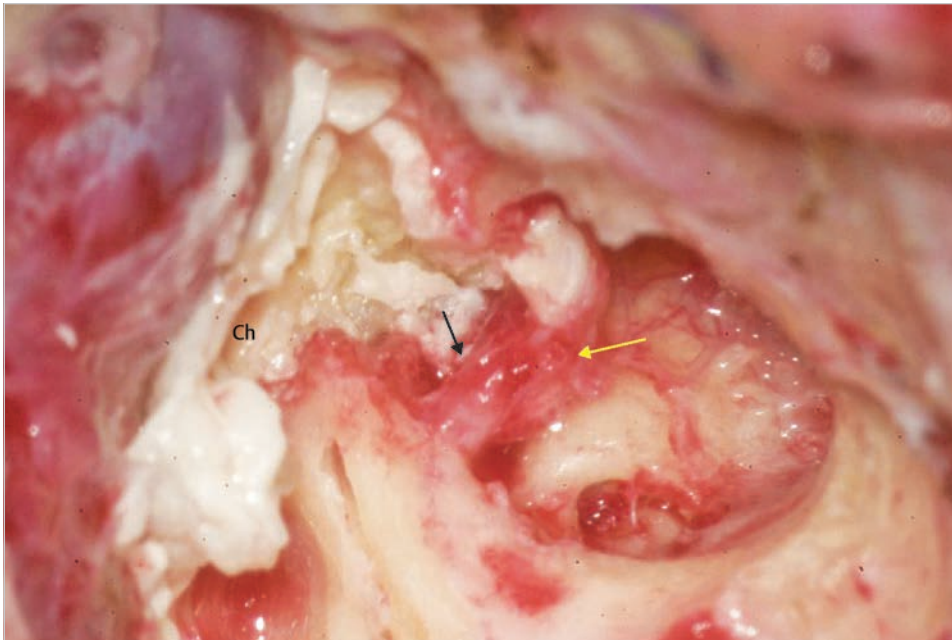


Fig. 14.246 Closer view. The facial nerve (*black arrow*) courses just inferomedially to the lateral semicircular canal, and just superiorly to the cochleariform process (*yellow arrow*). The superior aspect of the facial nerve is completely uncovered by the cholesteatoma infiltrating far medially. Note that the lateral semicircular canal is opened from superolateral aspect not to damage the facial nerve. Ch, cholesteatoma.

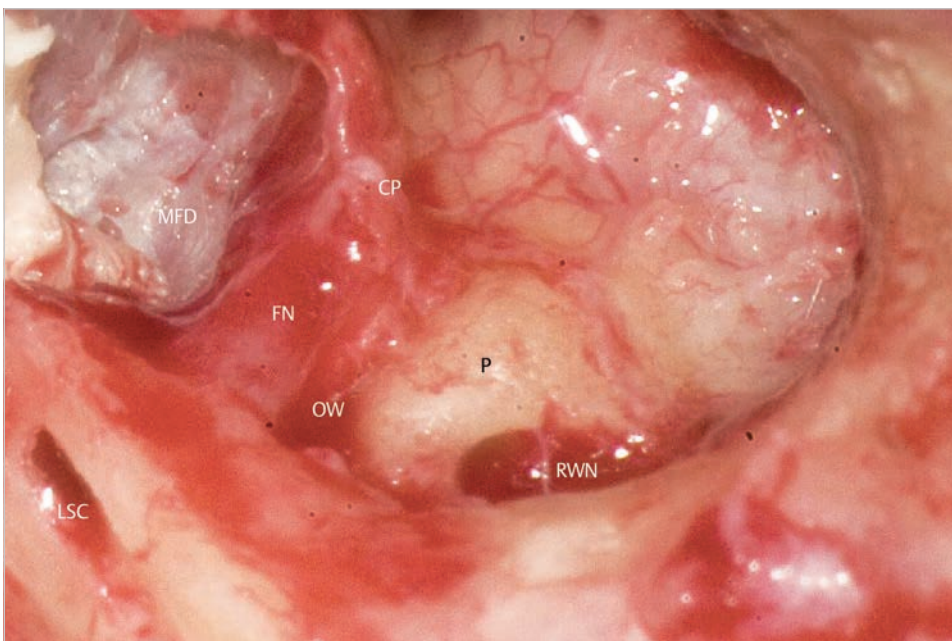


Fig. 14.247 Structures around the exposed facial nerve is shown. Note that the middle fossa dura covered with cholesteatoma is very low. CP, cochleariform process; FN, facial nerve; LSC, lateral semicircular canal; MFD, middle fossa dura; OW, oval window; P, promontory; RWN, round window niche.

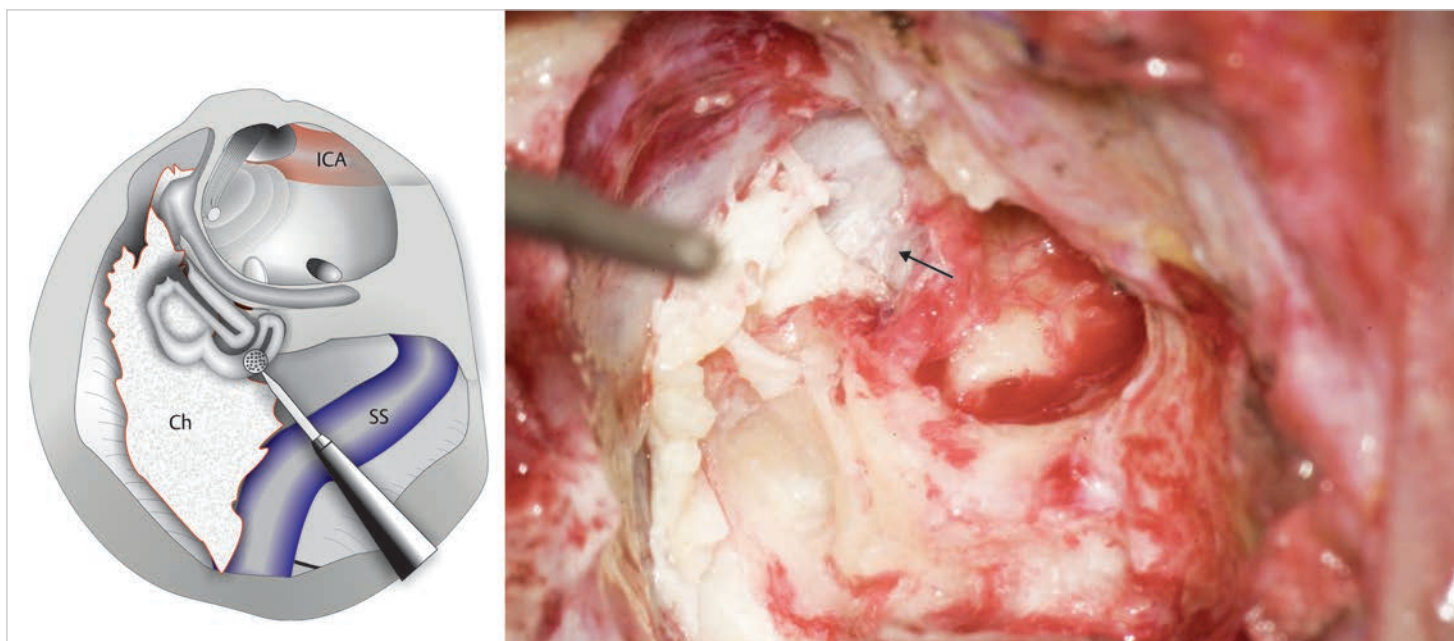


Fig. 14.248 The superior and lateral semicircular canals block access to the cholesteatoma advanced medially. Note that the middle fossa dura is still covered with thin matrix (*arrow*). Ch, cholesteatoma; ICA, internal carotid artery; SS, sigmoid sinus.



Fig. 14.249 Cholesteatoma encompassing the labyrinth is shown. The matrix also covered the posterior fossa dura (*arrow*). FN, facial nerve.

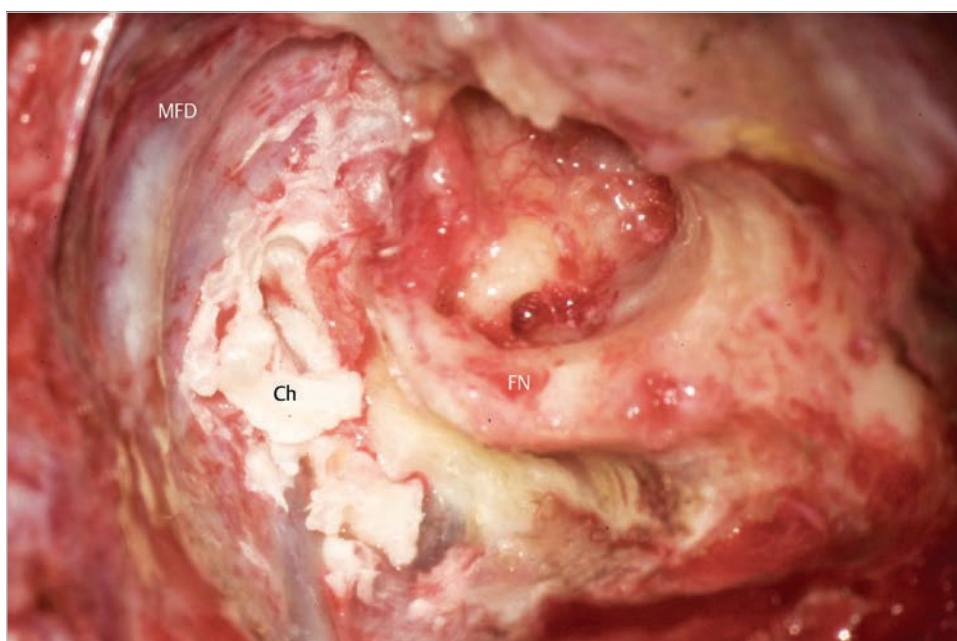


Fig. 14.250 The superior semicircular canal is removed. The cholesteatoma following the middle fossa dura to reach the area anteromedial to the cochlea is exposed. Dissection of the thin matrix covering the middle fossa dura is further carried out medially. The suspicious area for leaving matrix should be coagulated with bipolar, but use of a monopolar over dura is strictly prohibited. Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura.

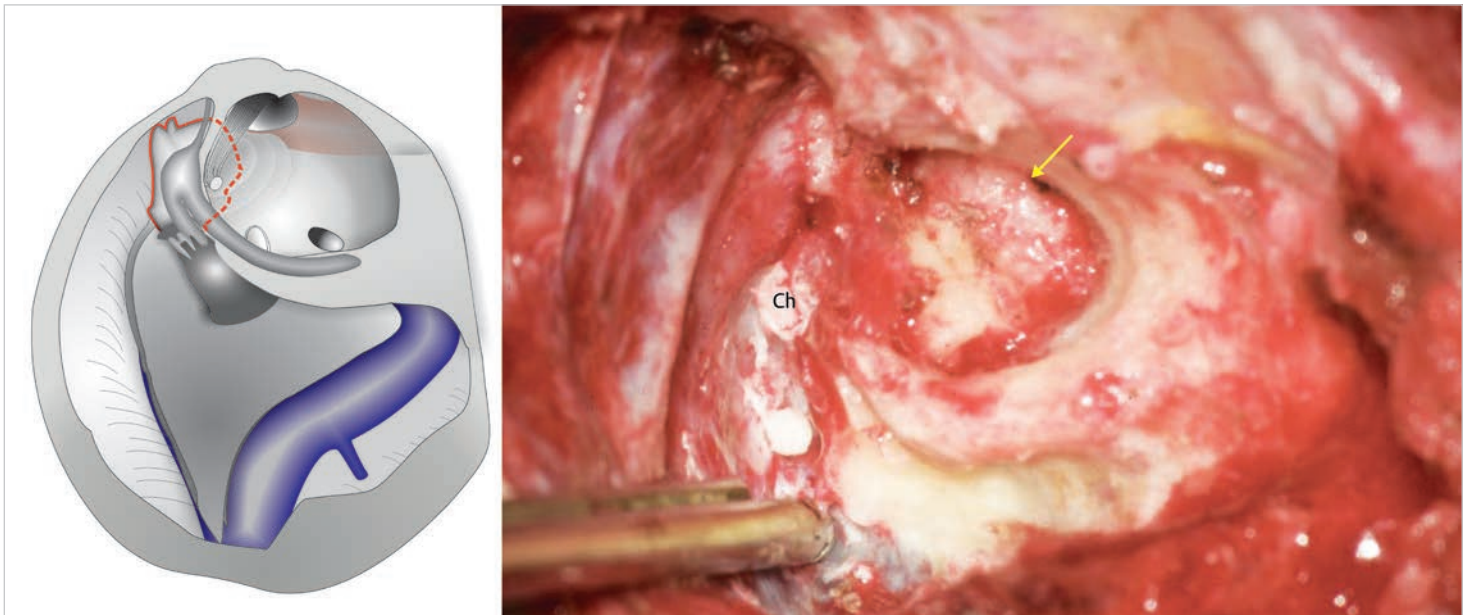


Fig. 14.251 The cholesteatoma matrix is dissected from the superior face of the geniculate ganglion. The carotid artery can be seen (arrow). Ch, cholesteatoma.



Fig. 14.252 The labyrinthine segment (white arrow) and the geniculate ganglion is exposed by cholesteatoma. To manage anteromedial extension of the cholesteatoma, posterior rerouting of the facial nerve is indicated. The tympanic segment of the facial nerve is exposed, and the great superficial petrosal nerve that connects the geniculate ganglion to the middle fossa dura is coagulated (yellow arrow) and severed. GG, geniculate ganglion.

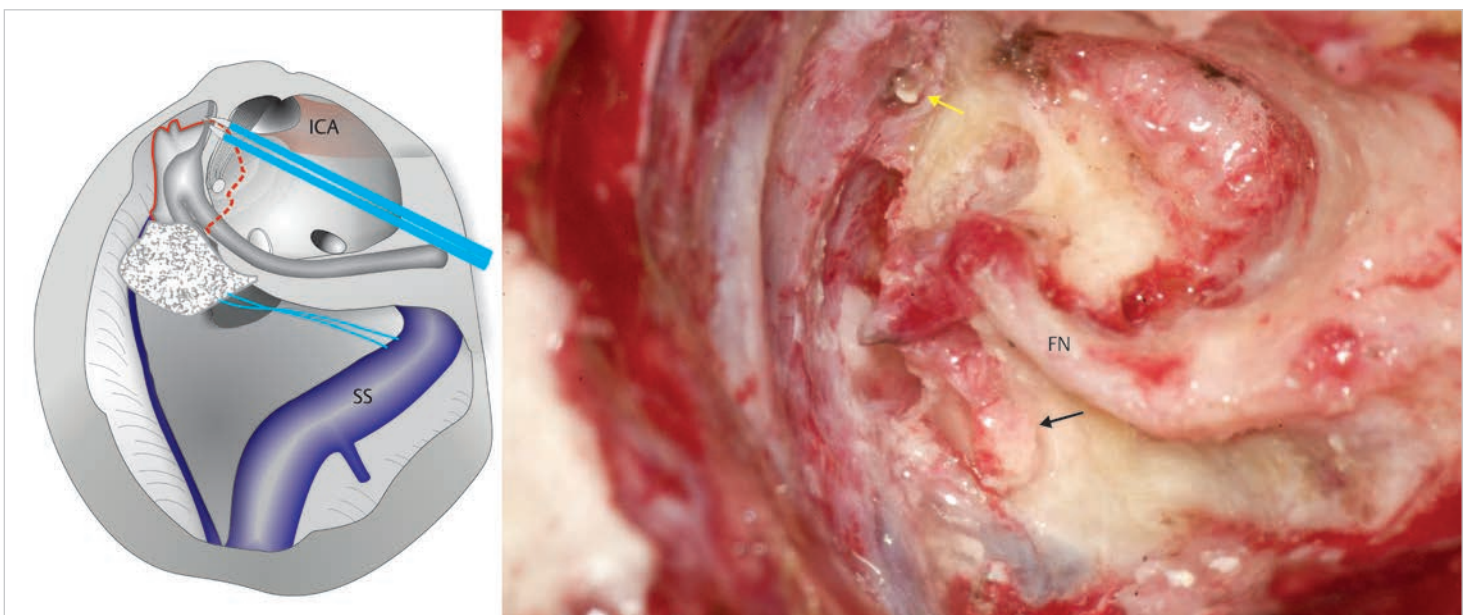


Fig. 14.253 The cochlea is drilled, and the fundus of the internal auditory canal is reached (black arrow). The distal end of the great superficial petrosal nerve is seen (yellow arrow). FN, facial nerve; ICA, internal carotid artery; SS, sigmoid sinus.

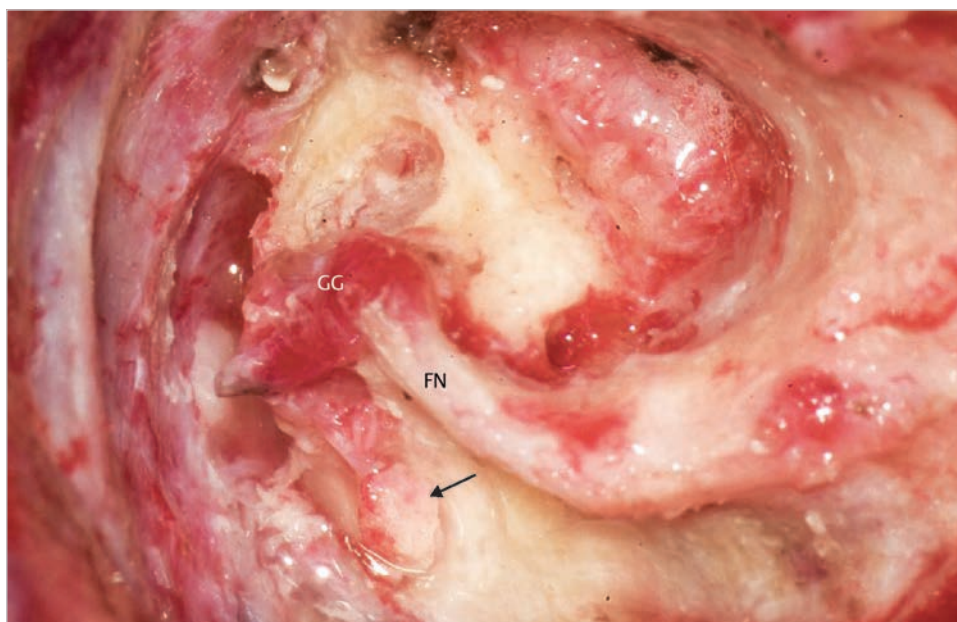


Fig. 14.254 Closer view. The geniculate ganglion is started to be mobilized posteriorly. The severed superior vestibular nerve is seen (arrow). FN, facial nerve; GG, geniculate ganglion.

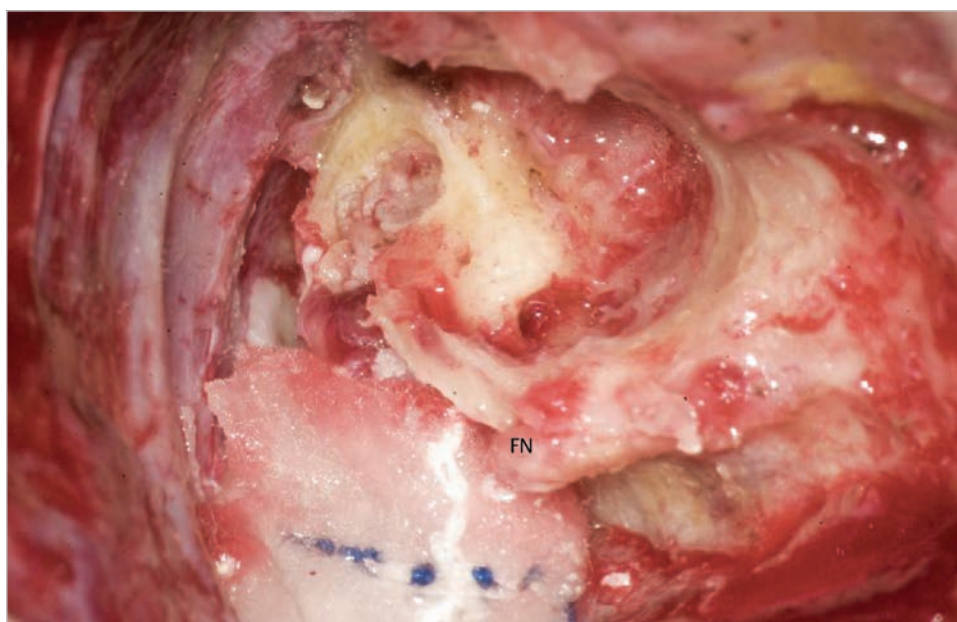


Fig. 14.255 The tympanic segment of the facial nerve is detached from the fallopian canal. The opening of the internal auditory canal is temporarily closed with cottonoid for further drilling to avoid debris falling into the intracranial space. FN, facial nerve.

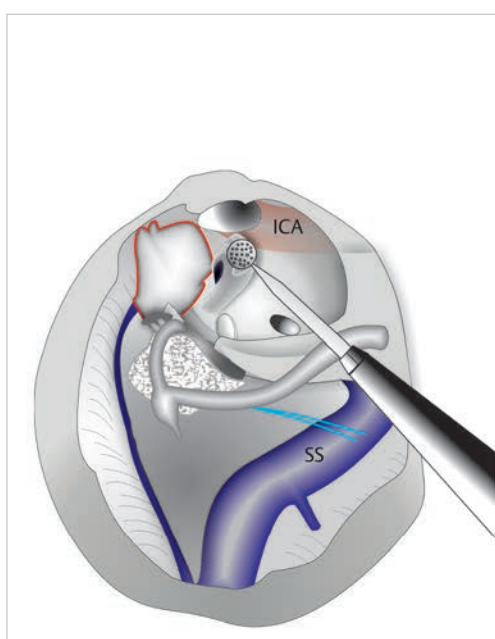


Fig. 14.256 The facial nerve is rerouted posteriorly to further drill the cochlea. The matrix located anteromedially to it is seen. The apical turn of the cochlea is seen (black arrow). FN, facial nerve; ICA, internal carotid artery; SS, sigmoid sinus.

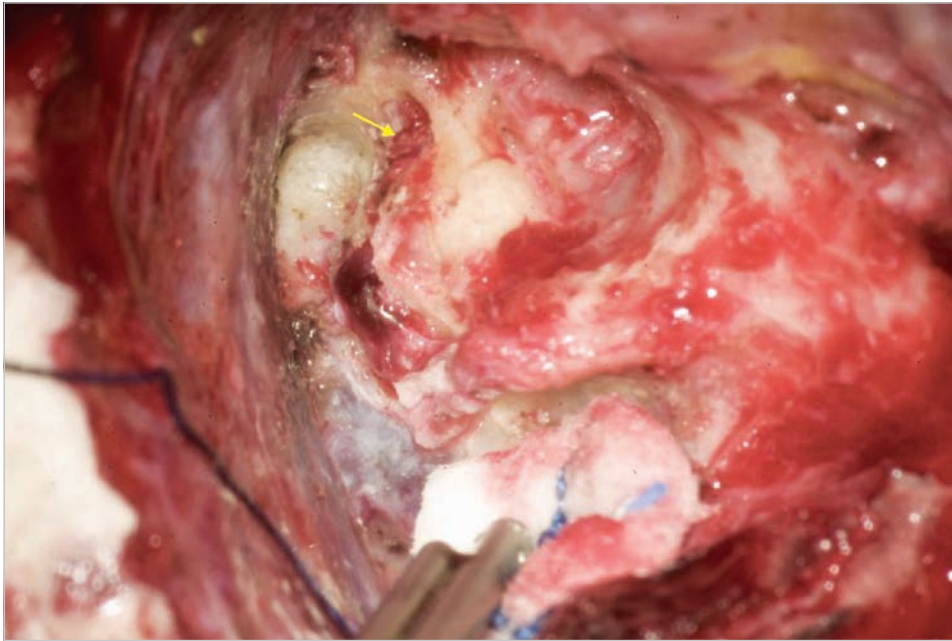


Fig. 14.257 Rerouting of the facial nerve posteriorly permits both further drilling of the cochlea and visualization of the matrix covering the back side of the facial nerve. A remnant of the basal turn of the cochlea (arrow) is obliterated with a piece of muscle.

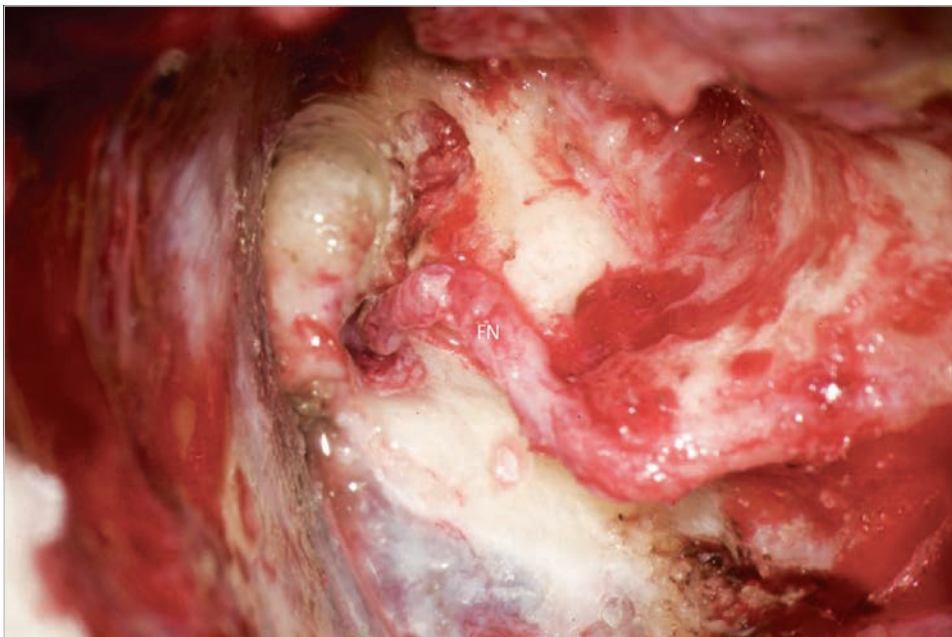


Fig. 14.258 Continuity of the nerve is preserved, and total removal of the cholesteatoma is achieved. Note that the removal of the cochlea creates sufficient opening to the area anteromedial to it. The opening of the internal auditory canal posterior to the facial nerve is obliterated with a piece of perichondrium. FN, facial nerve.



Fig. 14.259 The eustachian tube is closed with pieces of periosteum. Fibrin glue is applied to maintain route of the facial nerve. The cavity is obliterated with abdominal fat. The facial nerve function returned to grade III 1 year after the surgery. FN, facial nerve.

Case 14.11 (Left Ear)

See ▶Fig. 14.260, ▶Fig. 14.261, ▶Fig. 14.262, ▶Fig. 14.263, ▶Fig. 14.264, ▶Fig. 14.265, ▶Fig. 14.266, ▶Fig. 14.267, ▶Fig. 14.268, ▶Fig. 14.269, ▶Fig. 14.270, ▶Fig. 14.271, ▶Fig. 14.272, ▶Fig. 14.273, ▶Fig. 14.274, ▶Fig. 14.275.

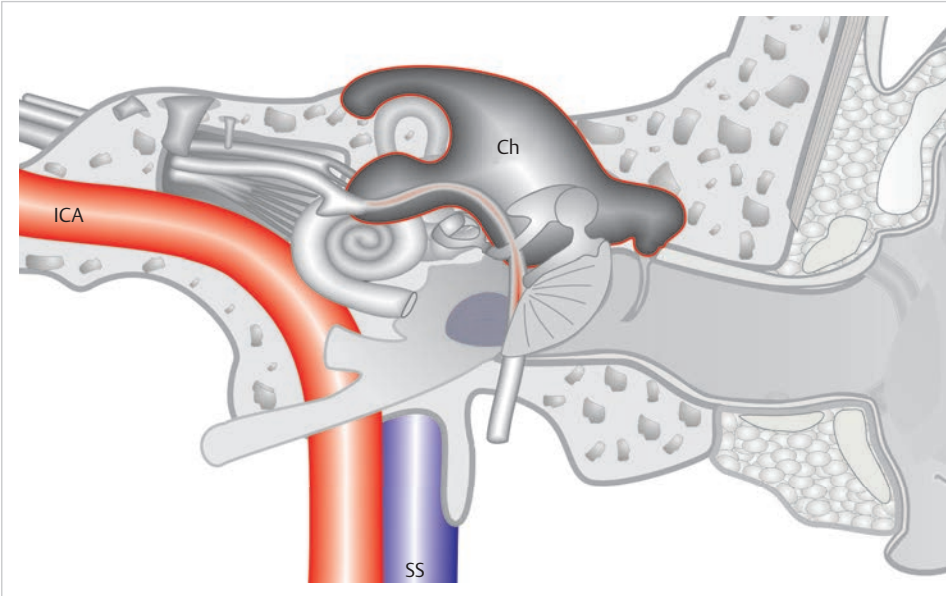


Fig. 14.260 A case of acquired supralabyrinthine cholesteatoma after temporal bone fracture with small cochlear fistula with facial palsy treated with transotic approach with reconstruction of the facial nerve. Ch, cholesteatoma; ICA, internal carotid artery; SS, sigmoid sinus.

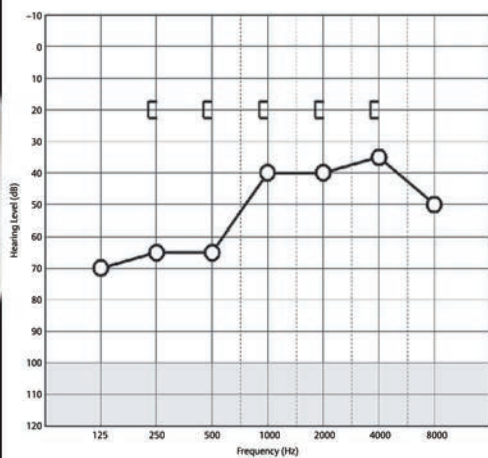


Fig. 14.261 The 26-year-old woman suffered from left temporal bone fracture 10 years ago, with temporary left facial palsy that recovered completely. Progressive left facial palsy developed 6 months before that reached H-B grade V at the presence of our office. Otoscopic examination shows fracture line on the superior wall of the bony meatus (arrows). Hearing examination revealed considerable conductive hearing loss in the left ear.



Fig. 14.262 The axial CT at the level of the vestibule shows presence of cholesteatoma eroding the medial face of the head of the malleus located anteromedially to the ossicular chain. A small cochlear fistula is identified (arrow). C, cochlea; Ch, cholesteatoma; I, incus; V, vestibule.

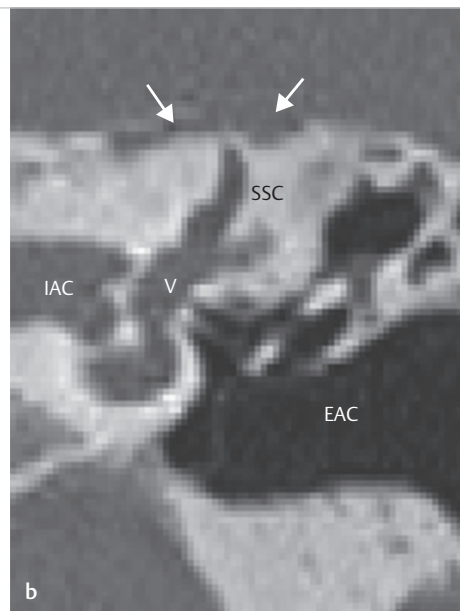
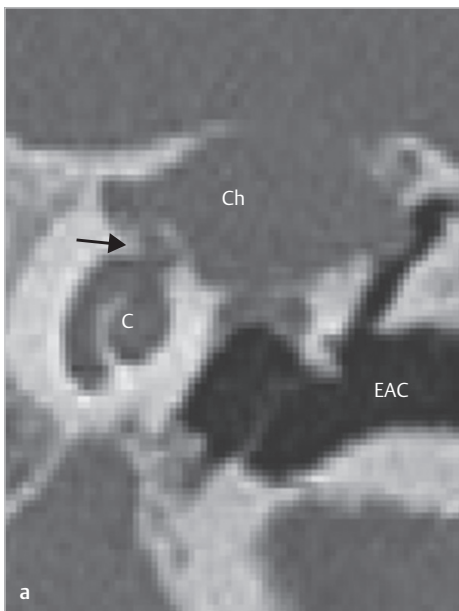


Fig. 14.263 Coronal section at the level of the cochlea (a) shows cholesteatoma eroding medial wall of the attic to reach the area medial to the labyrinthine segment of the facial nerve (black arrow). More posterior section (b) revealed infiltration of cholesteatoma (white arrows) along the middle fossa dura surpassing the superior semicircular canal. C, cochlea; Ch, cholesteatoma; EAC, external auditory canal; IAC, internal auditory canal; SSC, superior semicircular canal; V, vestibule.

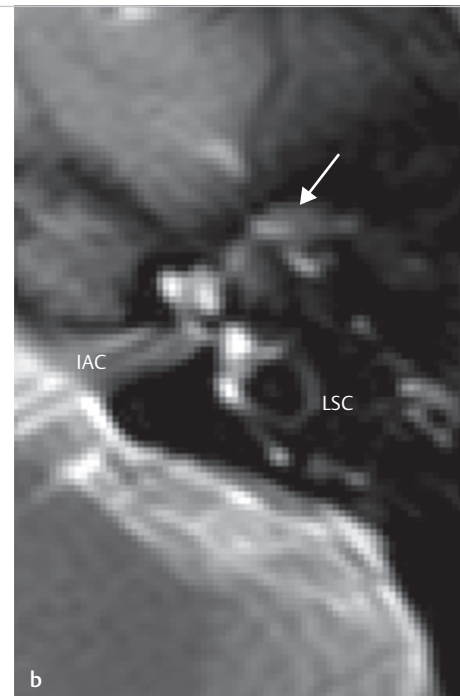
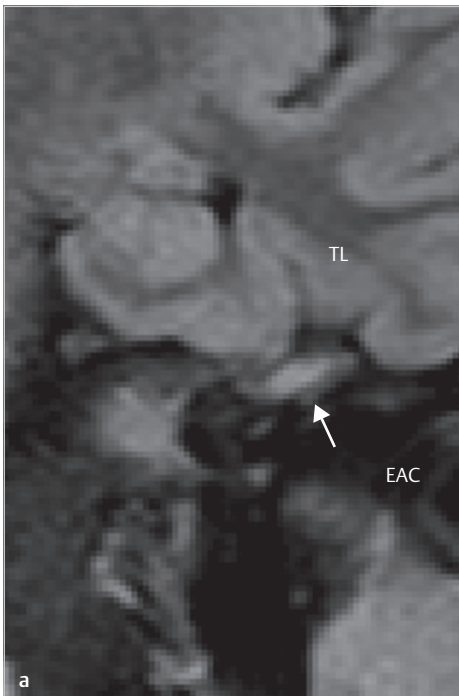


Fig. 14.264 The coronal section of T1-weighted MRI (a) shows mid signal intensity under the temporal lobe, and the axial section of T2-weighted MRI (b) at the level of the lateral semicircular canal shows high signal intensity located laterally to the cochlea, corresponding to the presence of cholesteatoma (arrows). EAC, external auditory canal; IAC, internal auditory canal; LSC, lateral semicircular canal; TL, temporal lobe.

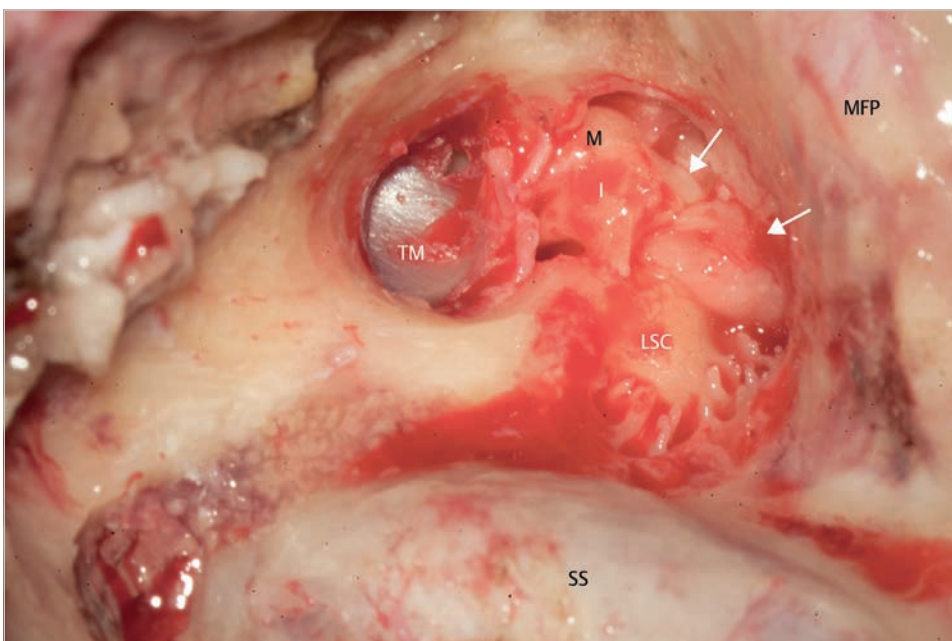


Fig. 14.265 The posterior wall of the external auditory canal is removed, and the middle fossa dura and the sigmoid sinus are skeletonized. Cholesteatoma filling the space medial to the ossicular chain is seen. I, incus; LSC, lateral semicircular canal; M, malleus; MFP, middle fossa plate; SS, sigmoid sinus; TM, tympanic membrane.

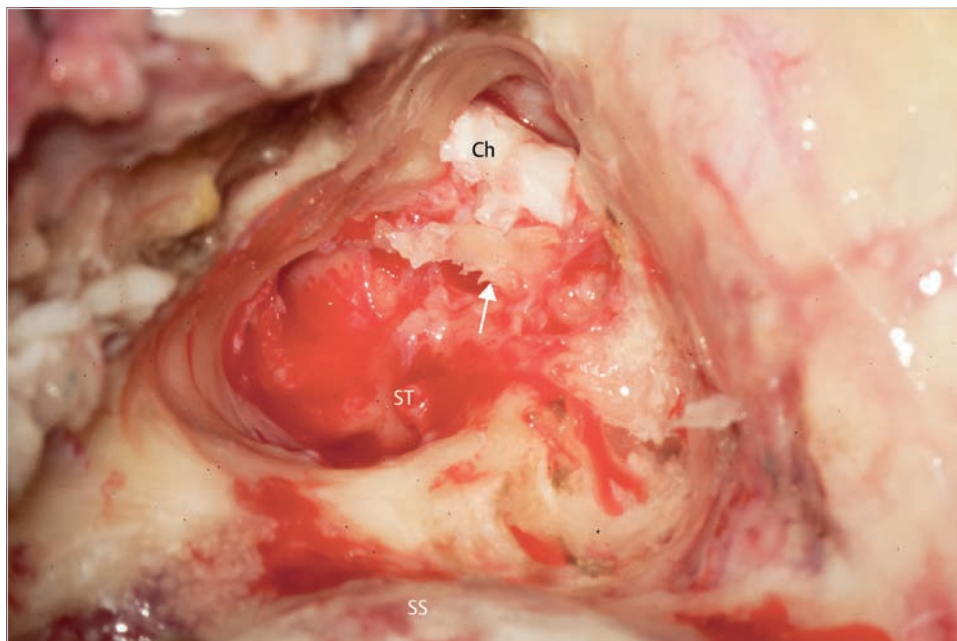


Fig. 14.266 The tympanic membrane is removed together with the malleus and the incus to expose the medial wall of the attic infiltrated by cholesteatoma. The bony plate (*arrow*) covering the cholesteatoma is fractured laterally to open the supratubal recess filled and eroded by the cholesteatoma. Ch, cholesteatoma; SS, sigmoid sinus; ST, stapes.

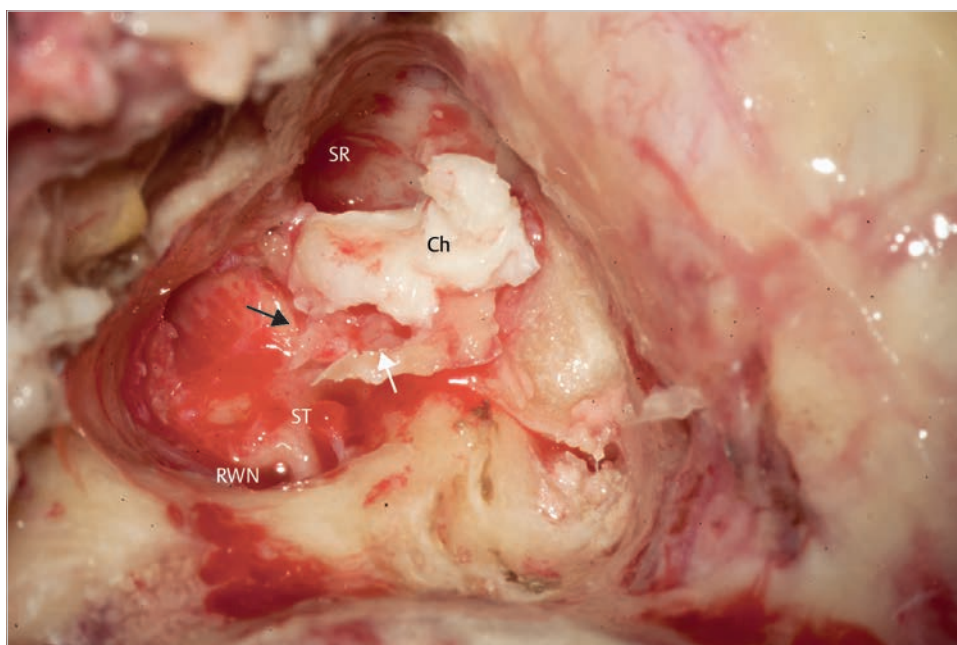


Fig. 14.267 The supratubal recess is further opened, and the cholesteatoma is followed medially. The tympanic segment of the facial nerve (*white arrow*) coursing just superiorly to the cochleariform process (*black arrow*) is seen. Ch, cholesteatoma; RWN, round window niche; SR, supratubal recess; ST, stapes.

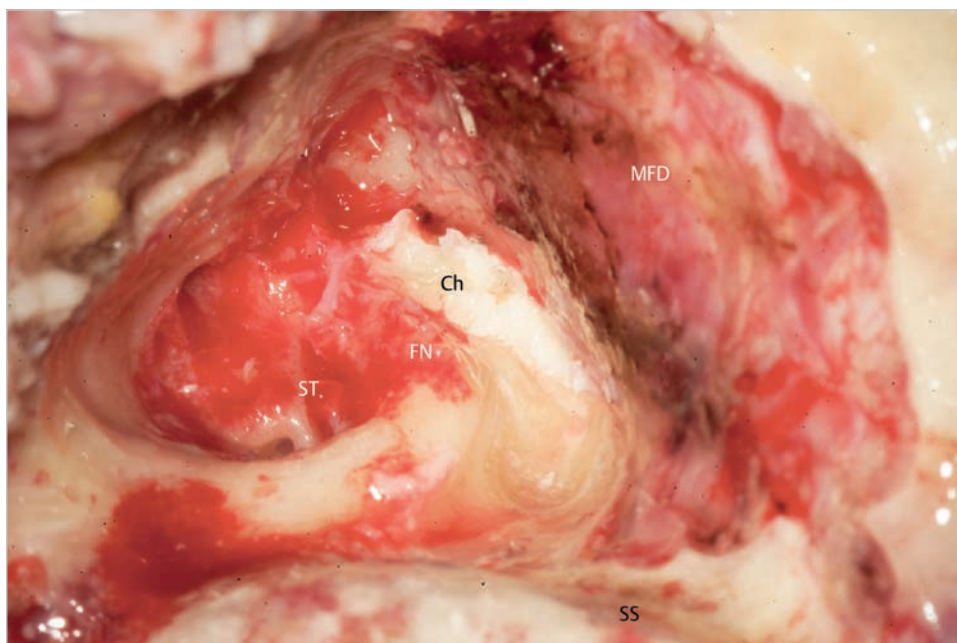


Fig. 14.268 Cholesteatoma going medially to the facial nerve is shown. To enlarge access to the cholesteatoma going medially beneath the middle fossa plate, the middle fossa plate lateral to the cholesteatoma is removed taking care not to damage the dura. The dura is coagulated and shrunk with bipolar to enlarge access to medial. Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura; ST, stapes.

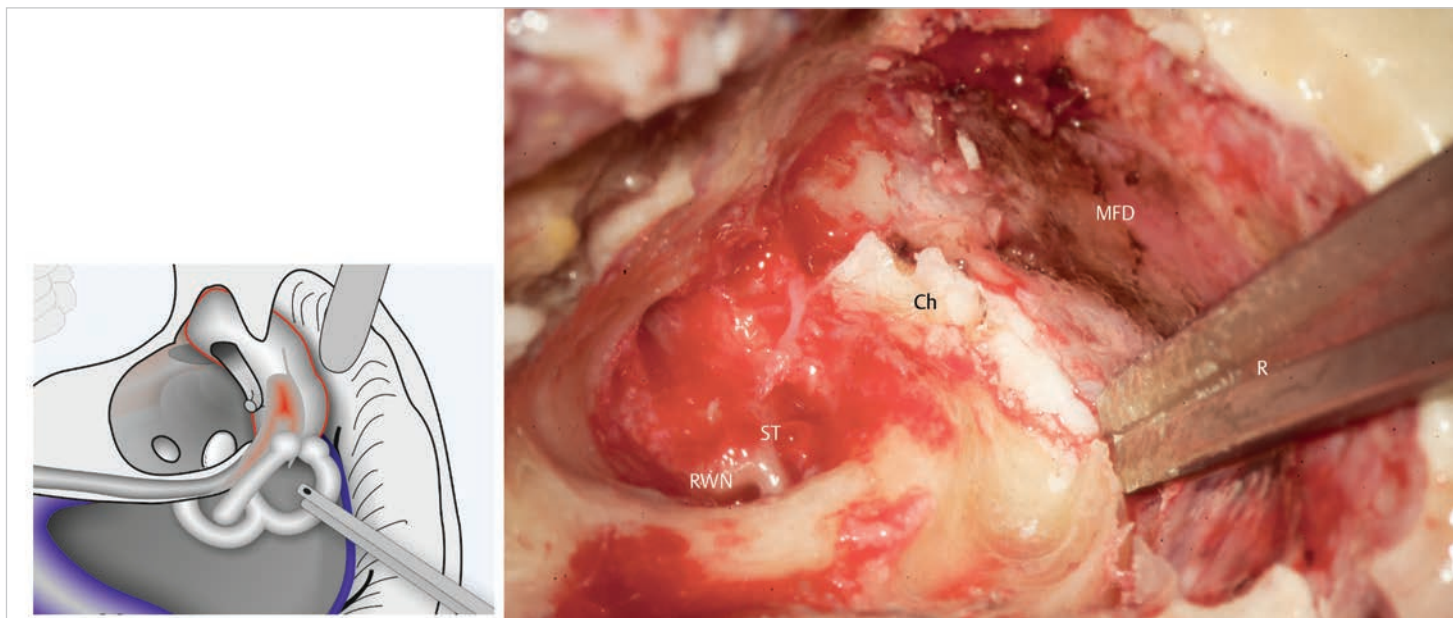


Fig. 14.269 The dura is pushed superiorly with the middle fossa retractor. The cholesteatoma going medially along the dura is seen. Ch, cholesteatoma; MFD, middle fossa dura; R, retractor; RWN, round window niche; ST, stapes.

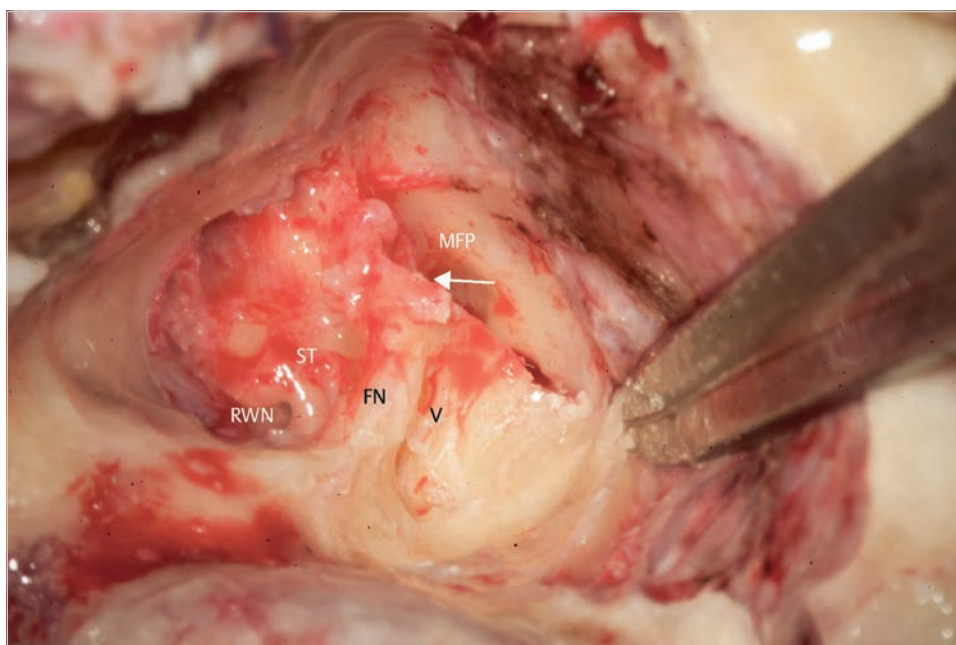


Fig. 14.270 Semicircular canals are removed, and the vestibule is opened. To remove cholesteatoma infiltrating the space between the facial nerve and the middle fossa plate. The nerve is extensively exposed and severely damaged at the level of the geniculate ganglion (arrow). FN, facial nerve; MFP, middle fossa plate; RWN, round window niche; ST, stapes; V, vestibule.

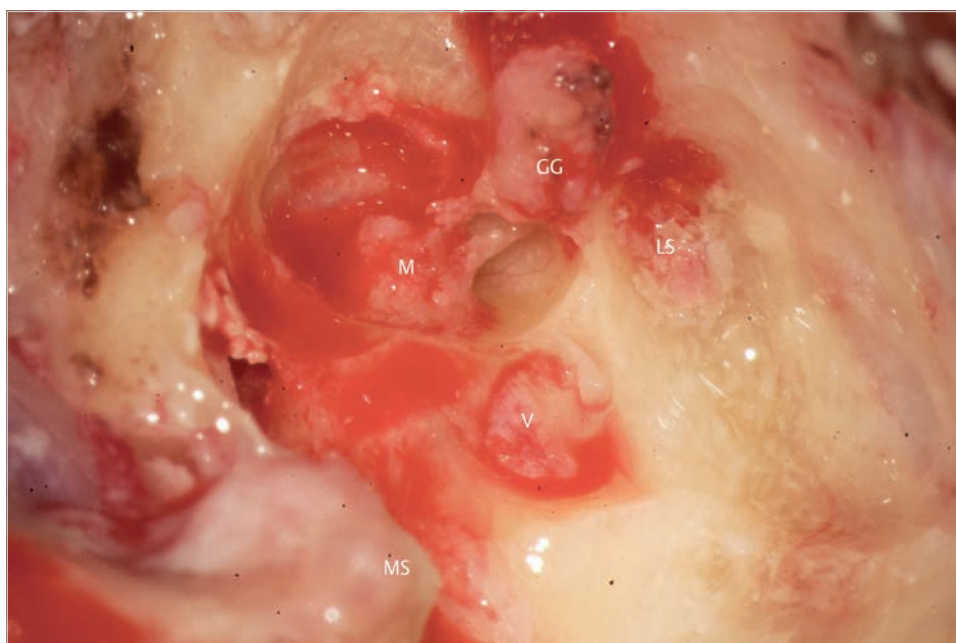


Fig. 14.271 The facial nerve is severed, and the cochlea and the vestibule are drilled to follow the labyrinthine segment of the facial nerve medially to sufficiently expose a healthy portion of the nerve. GG, geniculate ganglion; LS, facial nerve (labyrinthine segment); M, modiolus of cochlea; MS, facial nerve (mastoid segment); V, vestibule.

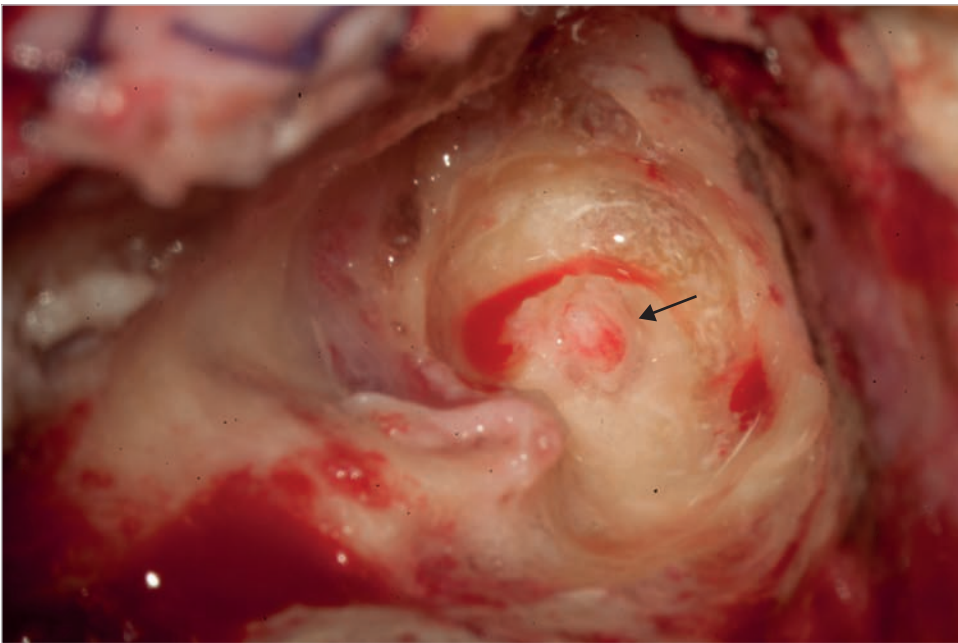


Fig. 14.272 Removal of the labyrinth is advanced to reach the area of the fundus of the internal auditory canal (arrow).

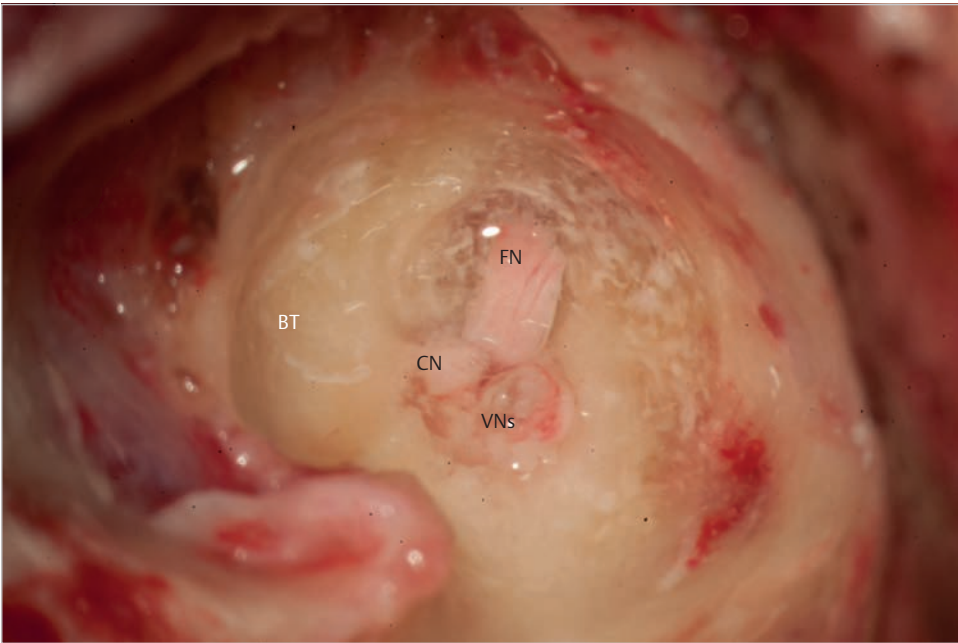


Fig. 14.273 The bony plate forming the fundus of the internal auditory canal is removed to expose nerves at the fundus. To reconstruct the facial nerve, each nerve should be identified clearly, and sufficient length of the facial nerve should be exposed without damaging it. BT, basal turn of cochlea; CN, cochlear nerve; FN, facial nerve; VNs, vestibular nerves.

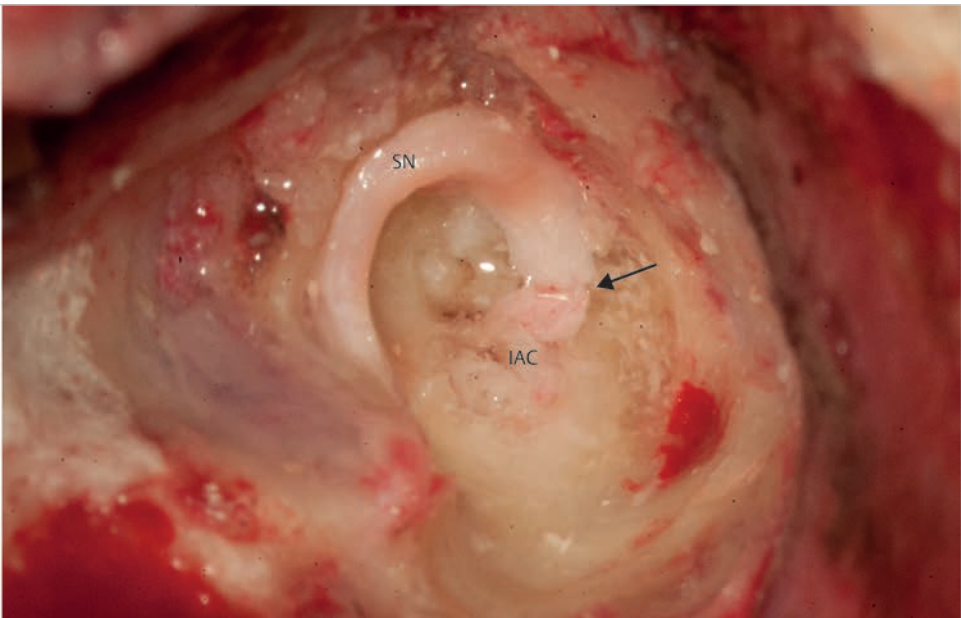
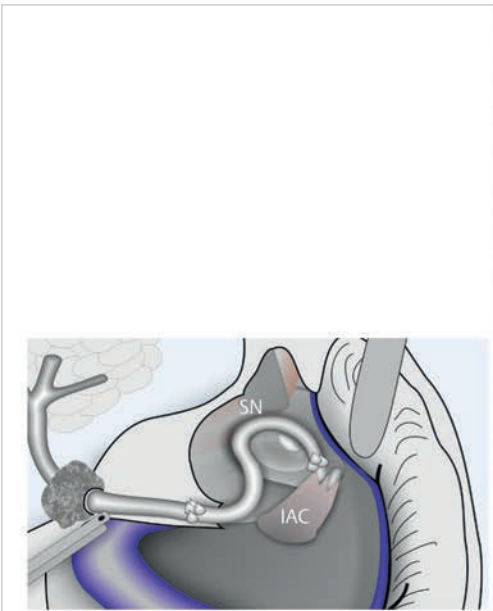


Fig. 14.274 The facial nerve is reconstructed with a cable grafting using a sural nerve graft stabilized by the groove of the basal turn of the cochlea. The proximal anastomosis is seen clearly (arrow). IAC, internal auditory canal; SN, sural nerve graft.

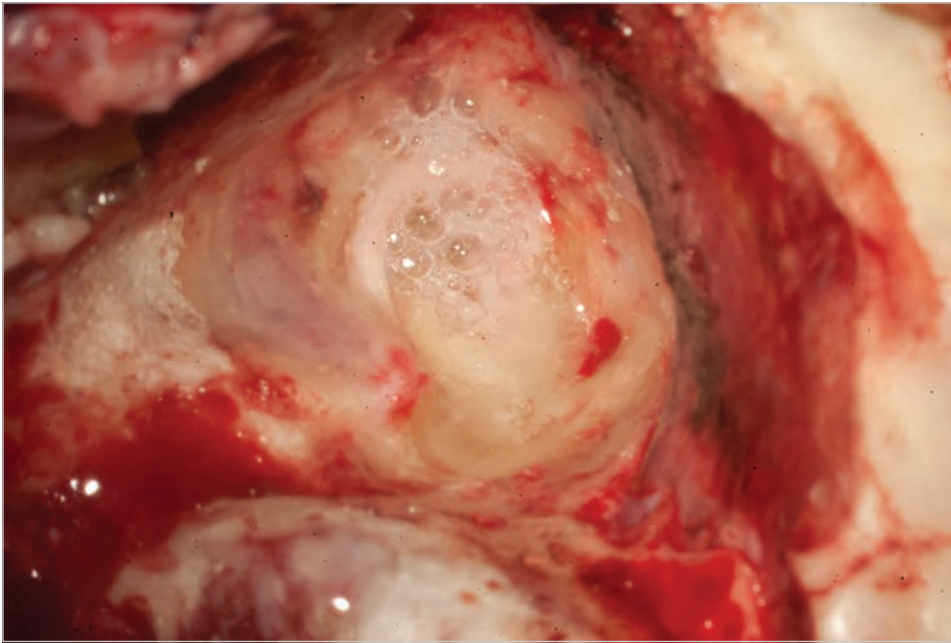


Fig. 14.275 Two anastomoses are secured by fascia, and the graft is fixed with fibrin glue.

Case 14.12 (Right Ear)

See ▶ Fig. 14.276, ▶ Fig. 14.277, ▶ Fig. 14.278, ▶ Fig. 14.279, ▶ Fig. 14.280, ▶ Fig. 14.281, ▶ Fig. 14.282, ▶ Fig. 14.283, ▶ Fig. 14.284, ▶ Fig. 14.285, ▶ Fig. 14.286, ▶ Fig. 14.287, ▶ Fig. 14.288, ▶ Fig. 14.289, ▶ Fig. 14.290, ▶ Fig. 14.291, ▶ Fig. 14.292, ▶ Fig. 14.293.

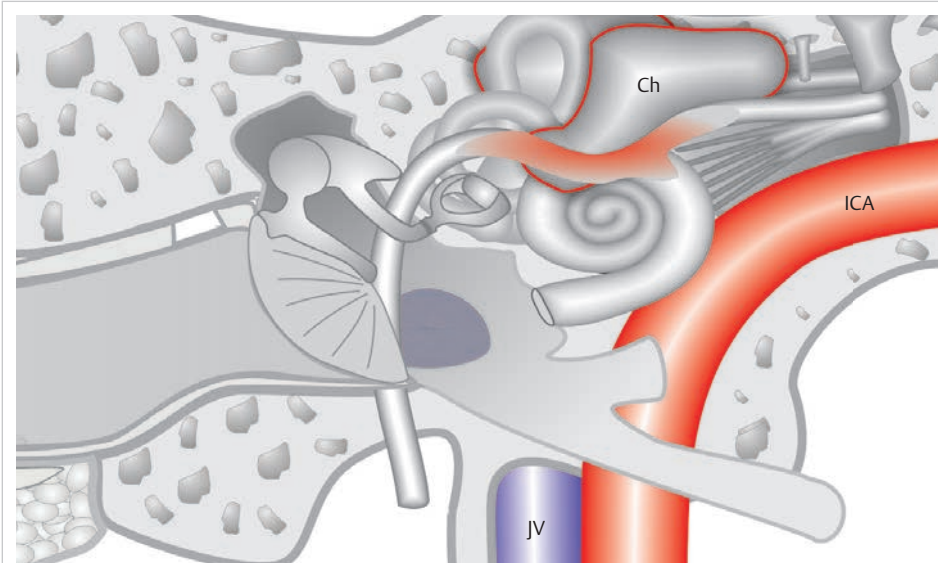


Fig. 14.276 A case of congenital supralabyrinthine petrous bone cholesteatoma with incomplete facial nerve palsy with erosion in the cochlea, the posterior labyrinth, and the internal auditory canal, treated with transotic approach with facial nerve reconstruction. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

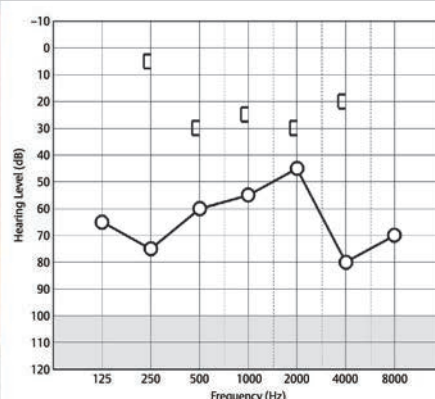


Fig. 14.277 The 48-year-old patient suffered from slowly progressive hearing loss and facial nerve palsy for years, and radiologic examination revealed presence of petrous bone cholesteatoma. A preoperative facial nerve palsy with synkinesis is graded to be III in H-B system. The preoperative otoscopy shows normal tympanic membrane. Preoperative audiogram shows conductive hearing loss of 50 dB with good bone conduction. The contralateral ear remains normal hearing level of 10 dB.

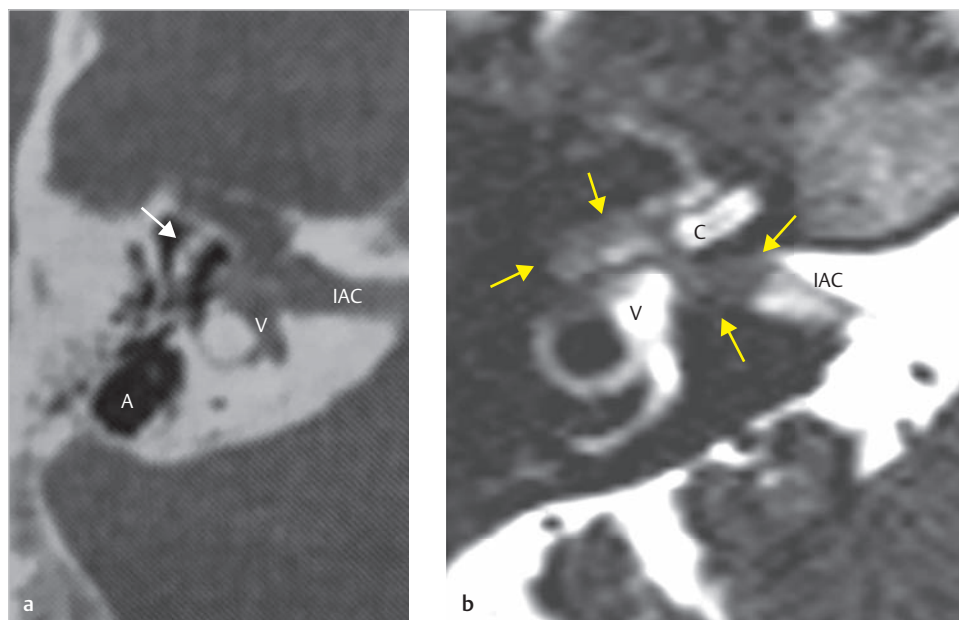


Fig. 14.278 The preoperative axial CT (a) shows presence of bone erosion in the vestibule and the lateral part of the internal auditory canal. No cholesteatoma is seen near the ossicular chain (white arrow) and the antrum. The T2-weighted MRI (b) shows medial extension of the cholesteatoma (yellow arrows) surpassing the labyrinth invaginating into the lateral end of the external auditory canal. A, antrum; C, cochlea; IAC, internal auditory canal; V, vestibule.

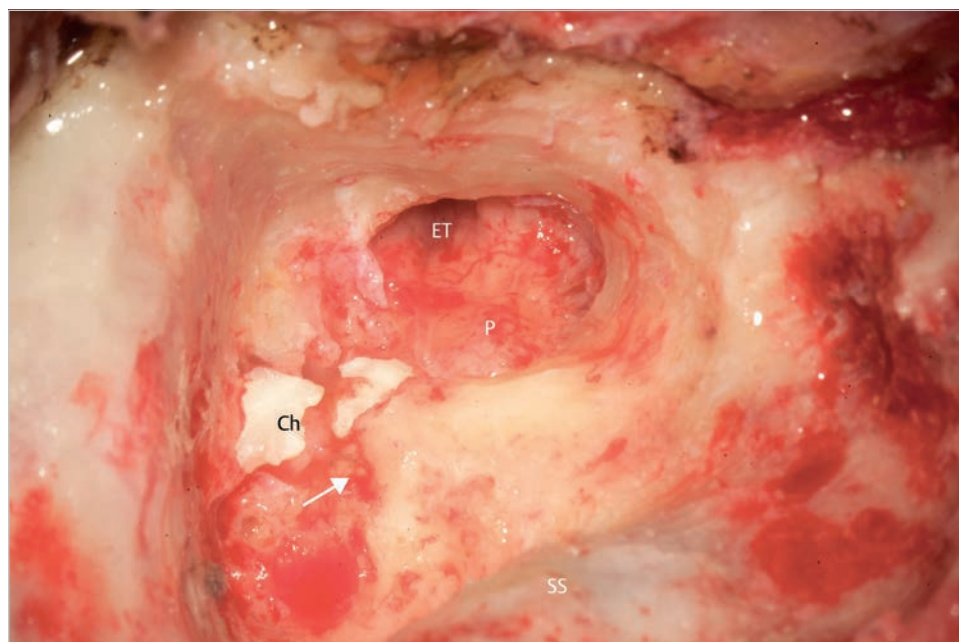


Fig. 14.279 After removing the tympanomeatal flap, canal wall down mastoidectomy is carried out to expose cholesteatoma infiltrating the medial wall of the attic. A fistula is identified in the lateral semicircular canal (arrow). Ch, cholesteatoma; ET, eustachian tube; P, promontory; SS, sigmoid sinus.

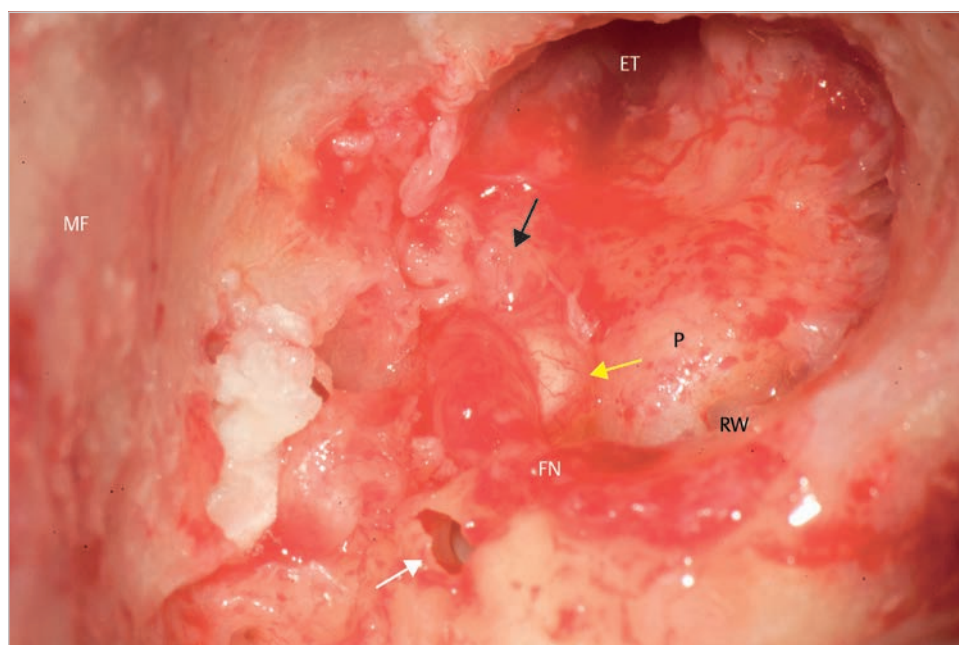


Fig. 14.280 The cholesteatoma covering the tympanic segment of the facial nerve is dissected. The nerve exposed and inflamed under the cholesteatoma is seen. The cholesteatoma occupying the vestibule and the area of the oval window pushes up the tympanic segment (yellow arrow). The nerve is followed posteriorly to expose a healthy part of the mastoid segment. A large fistula is seen in the lateral semicircular canal (white arrow). ET, eustachian tube; FN, facial nerve; MF, middle fossa; P, promontory; RW, round window.

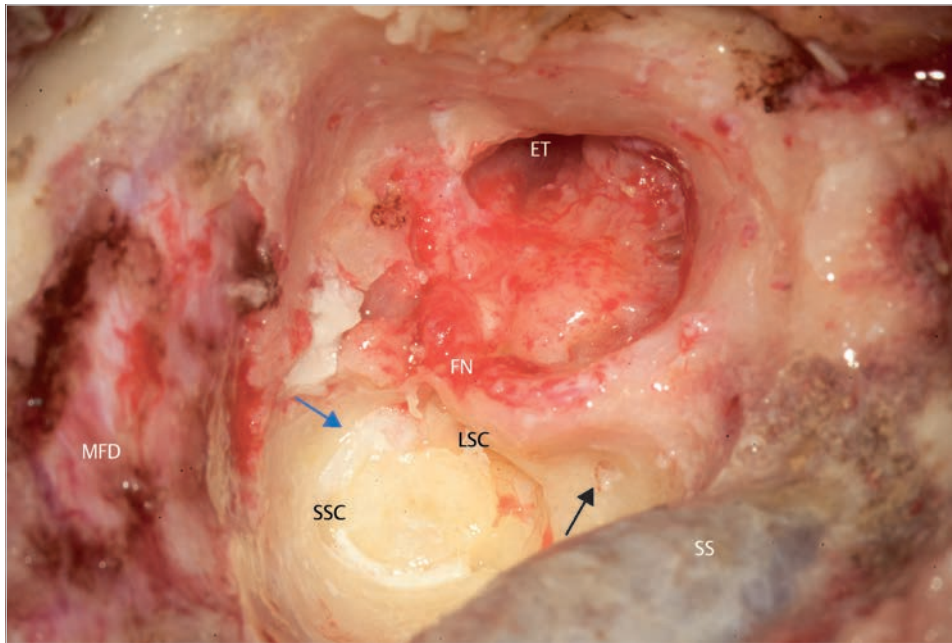


Fig. 14.281 Labyrinthectomy is carried out. An opening of the posterior semicircular canal is seen (*black arrow*). The superior semicircular canal is infiltrated by cholesteatoma from medial (*blue arrow*). ET, eustachian tube; FN, facial nerve; LSC, lateral semicircular canal; MFD, middle fossa dura; SS, sigmoid sinus; SSC, superior semicircular canal.

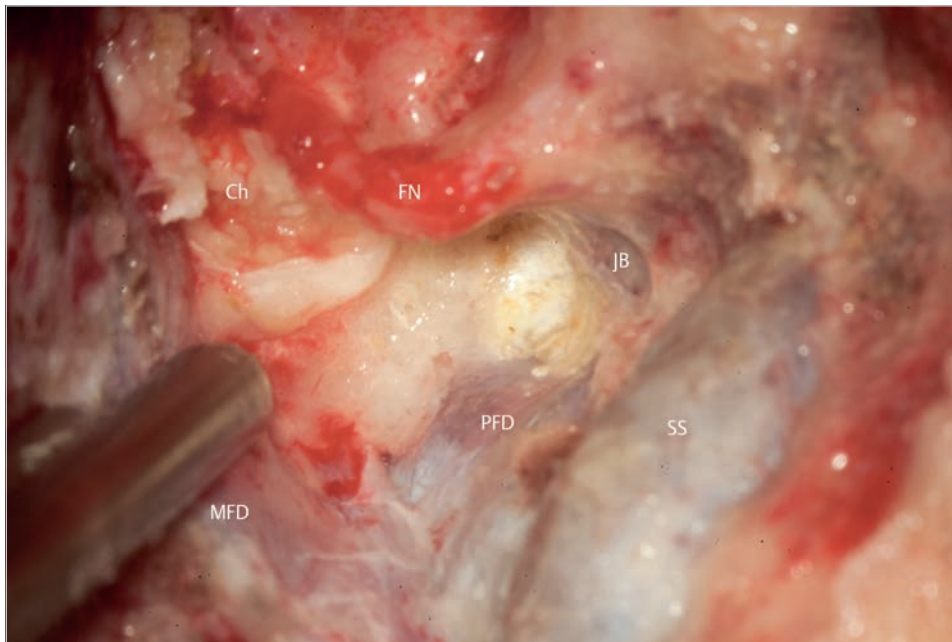


Fig. 14.282 To gain access to the area of the internal auditory canal, the bone between the facial nerve and the posterior fossa dura is drilled. The jugular bulb is identified inferiorly as a bluish area under the facial nerve. Ch, cholesteatoma; FN, facial nerve; JB, jugular bulb; MFD, middle fossa dura; PFD, posterior fossa dura; SS, sigmoid sinus.

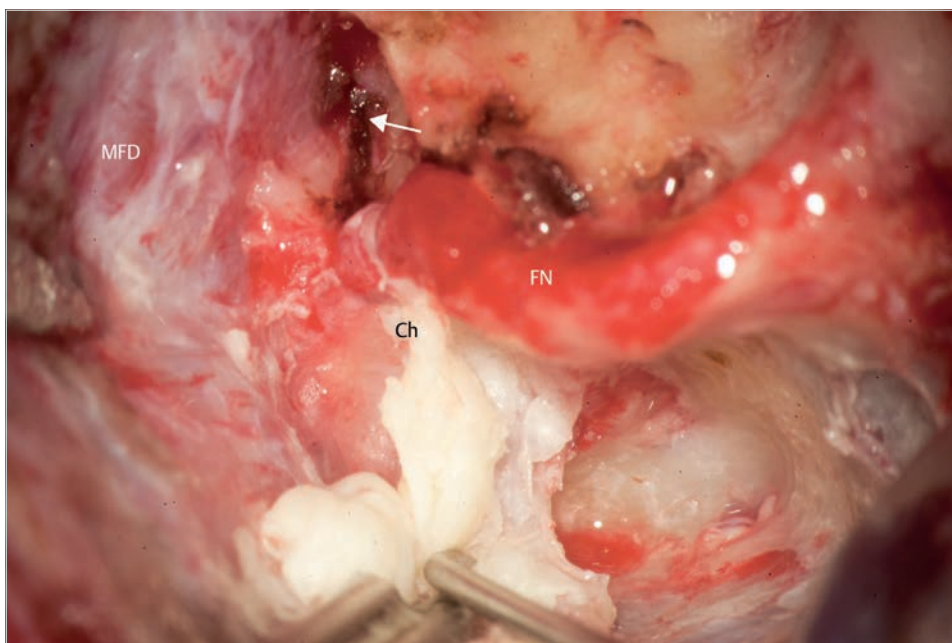


Fig. 14.283 The middle fossa dura is followed anteriorly, and cholesteatoma in the attic is exposed. Debulking of cholesteatoma revealed significant thinning of the nerve, and complete removal of tightly adherent thin matrix in situ is not possible. Posterior rerouting of the nerve is initially decided, and the nerve is mobilized posteriorly after cutting the great superficial petrosal nerve (*arrow*) near the middle fossa dura. Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura.

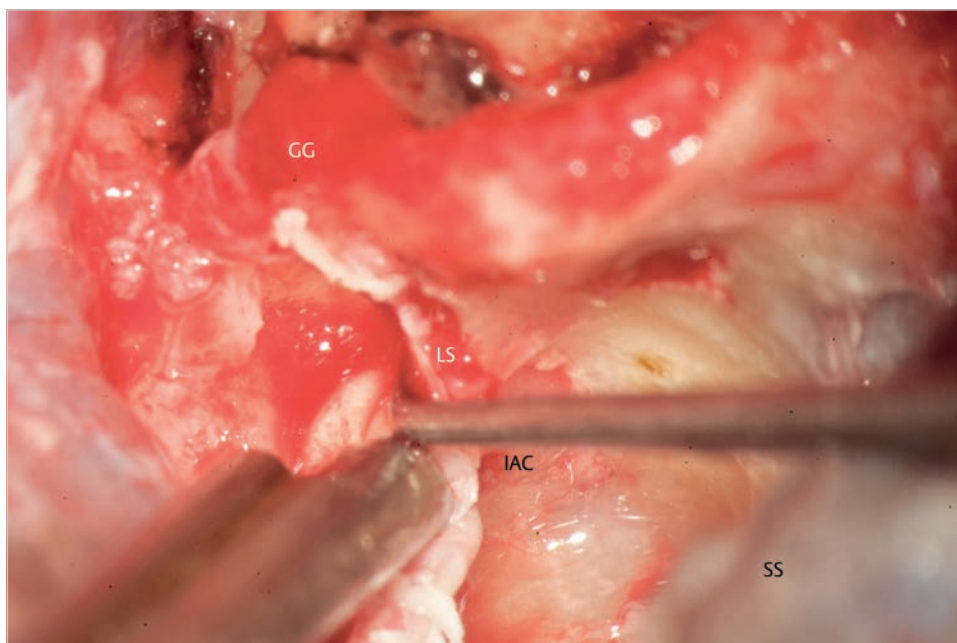


Fig. 14.284 Cholesteatoma is dissected from the posterior face of the internal auditory canal. GG, geniculate ganglion. IAC, internal auditory canal; LS, lateral sinus; SS, sigmoid sinus.

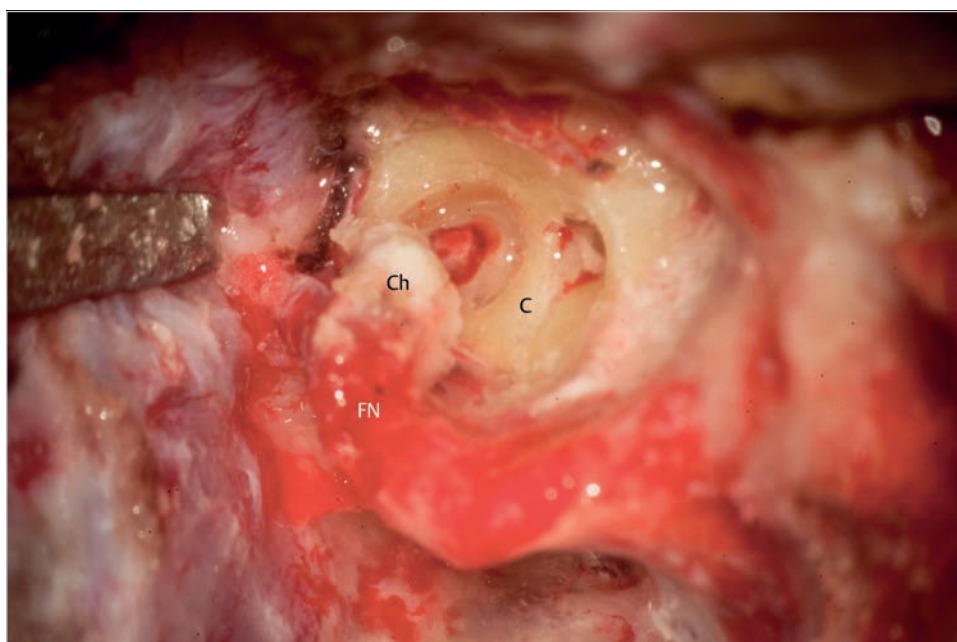


Fig. 14.285 The cholesteatoma under the facial nerve is pushed inferiorly toward the cochlea. C, cochlea; Ch, cholesteatoma; FN, facial nerve.

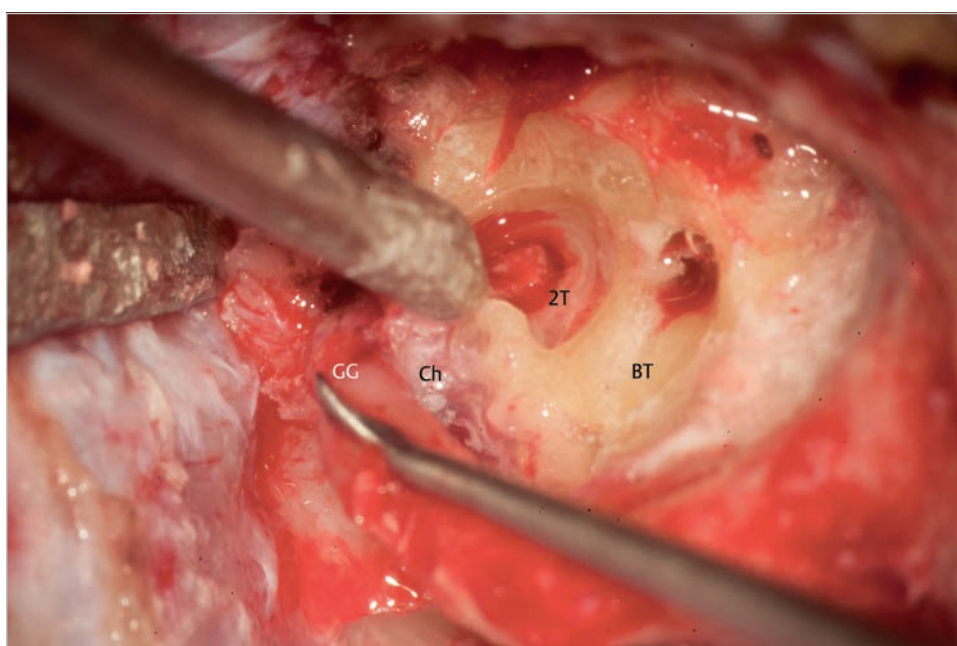


Fig. 14.286 Cholesteatoma matrix infiltrating the area between the geniculate ganglion and the cochlea is shown. BT, basal turn of cochlea; 2T, second turn of cochlea; Ch, cholesteatoma; GG, geniculate ganglion.

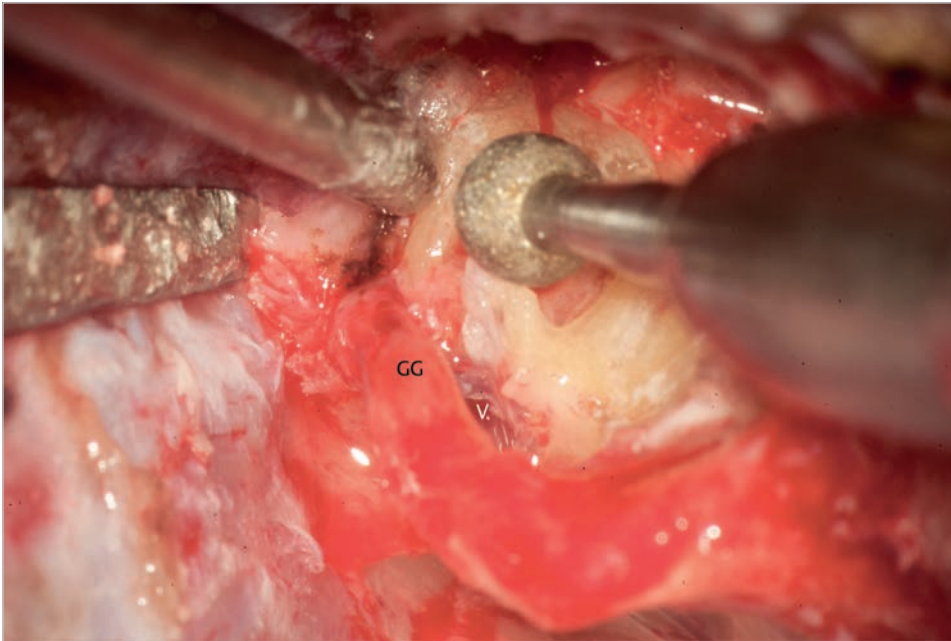


Fig. 14.287 The cochlea is further drilled to remove cholesteatoma infiltrating the inner ear. GG, geniculate ganglion; V, vestibule.

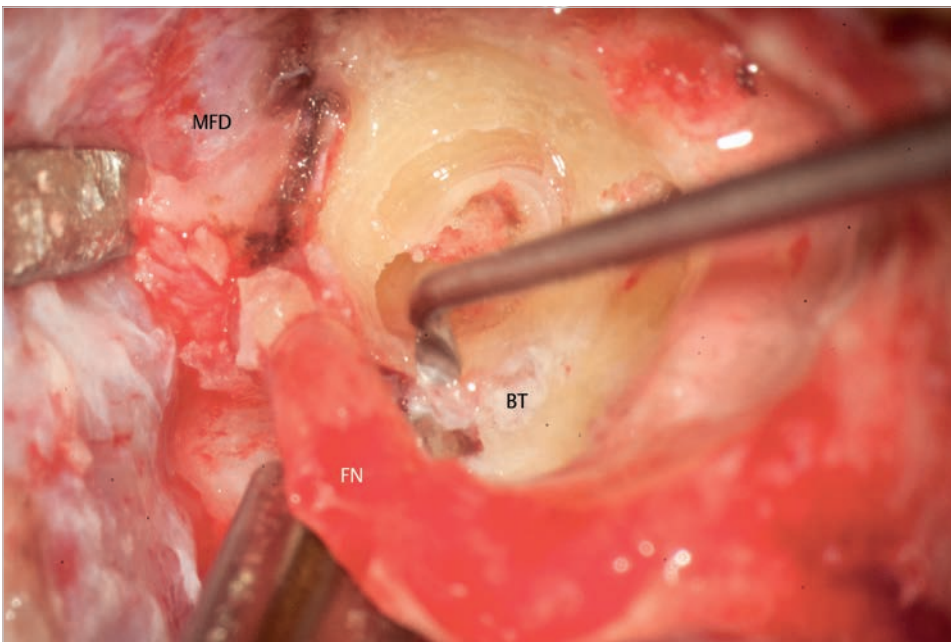


Fig. 14.288 The cholesteatoma infiltrating the basal turn of the cochlea and the vestibule is dissected. BT, basal turn of cochlea; FN, facial nerve; MFD, middle fossa dura.

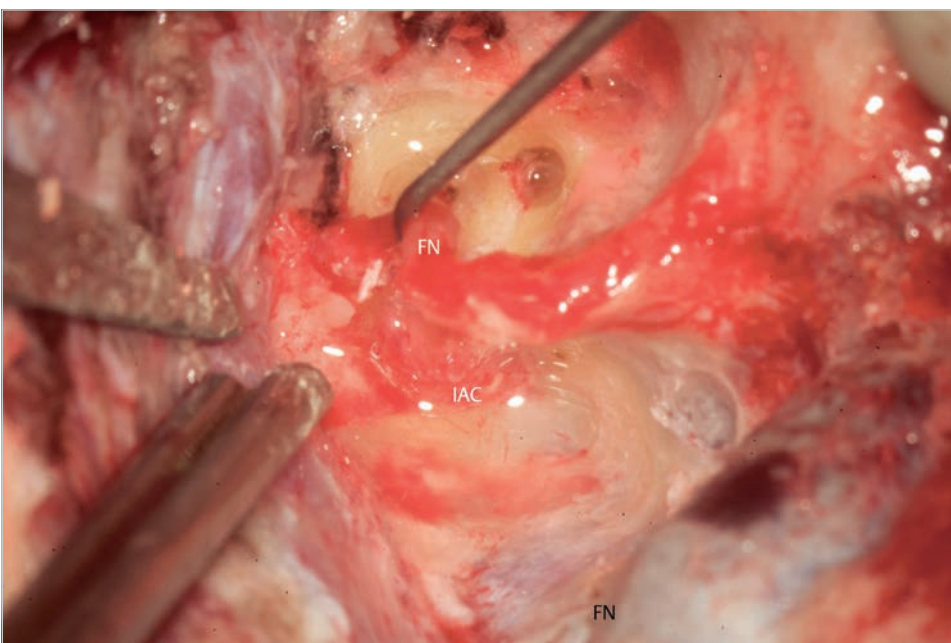


Fig. 14.289 Reevaluation of the nerve revealed incomplete removal of the cholesteatoma. Transection of the nerve is decided considering patient's age and damage of the nerve. FN, facial nerve; IAC, internal auditory canal.

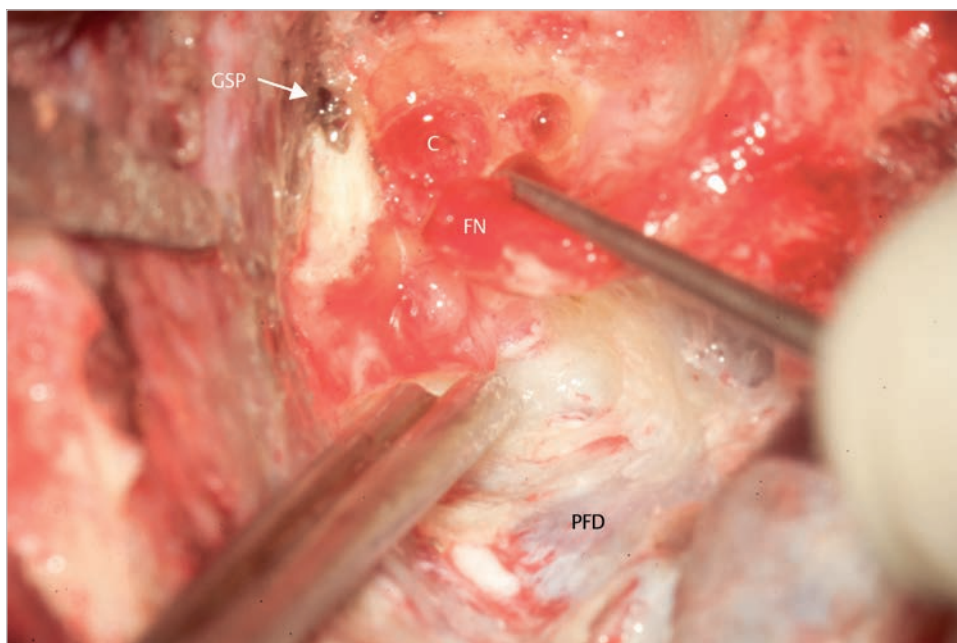


Fig. 14.290 The labyrinthine segment of the facial nerve got extremely thinned, and removal of very thin matrix from that segment seemed not possible. Taking preoperative facial nerve function (H-B grade III) into consideration, removal of the damaged segment to eradicate cholesteatoma is finally decided. C, cochlea; FN, facial nerve; GSP, great superficial petrosal nerve; PFD, posterior fossa dura.

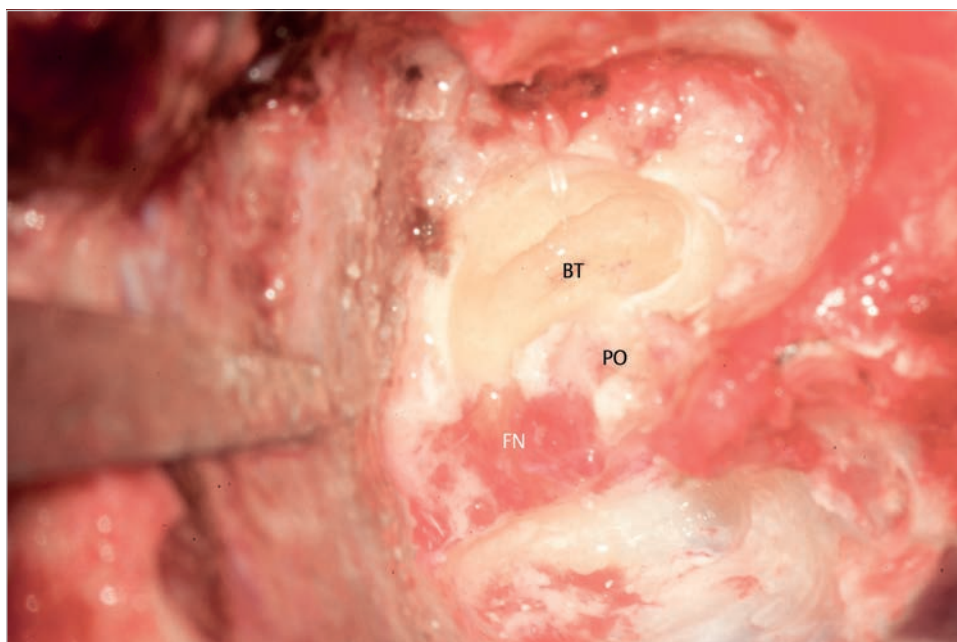


Fig. 14.291 The cochlea is further drilled to create an appropriate bed for nerve grafting. The groove corresponding to the basal turn can be used to accommodate the graft. Damaged segment of the facial nerve should be cut away with sharp scissors to reach healthy segment. To avoid postoperative CSF leak, the internal auditory canal is gently packed with periosteum leaving the distal stump of the facial nerve in place. BT, basal turn of cochlea; FN, facial nerve; PO, periosteum.

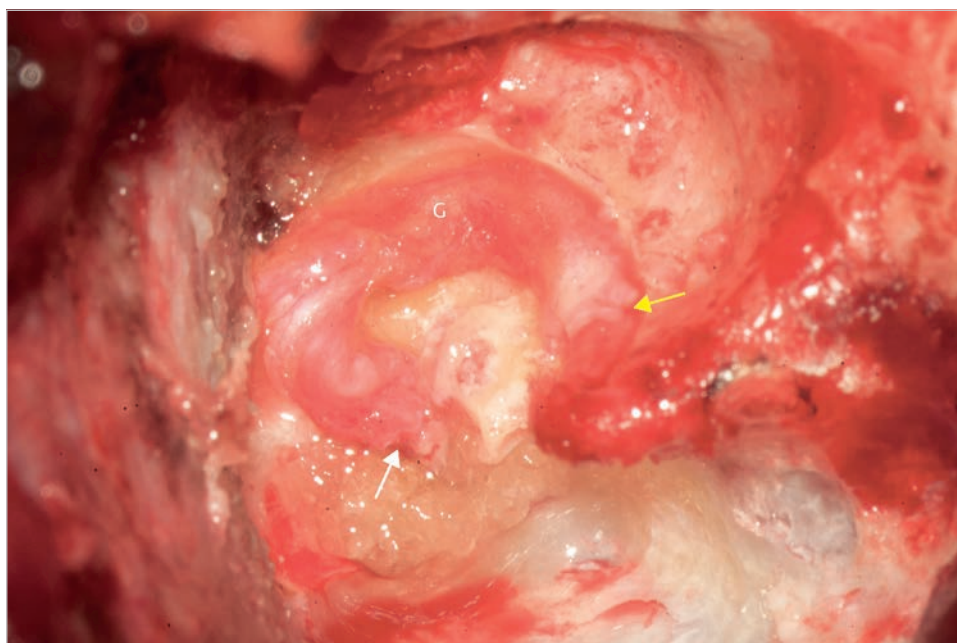


Fig. 14.292 The nerve graft is stabilized using the basal turn of the cochlea. The distal (yellow arrow), and the proximal (white arrow) anastomoses are seen. Fibrin glue is used to fix anastomoses and the graft, and abdominal fat is used to pack the cavity. G, nerve graft.

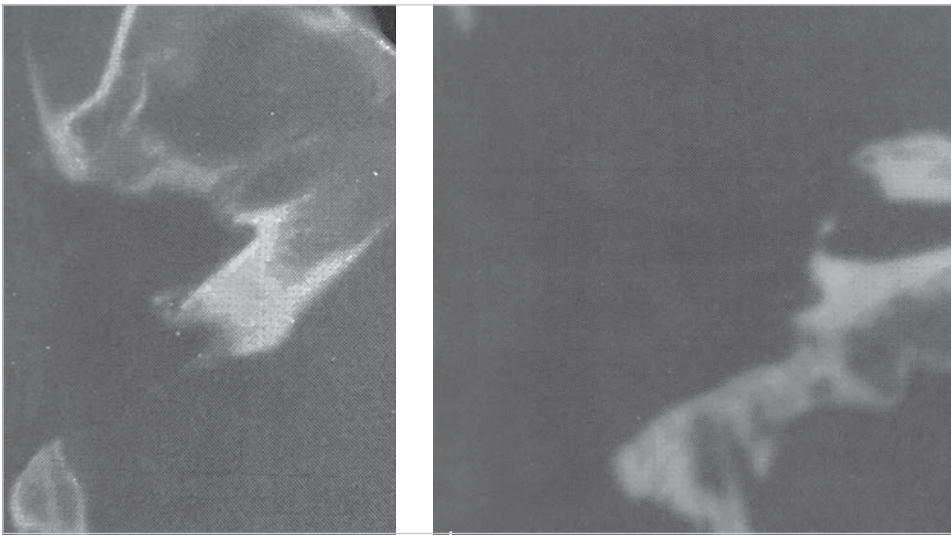


Fig. 14.293 The postoperative CT scans demonstrate extensive bone removal from the posterior fossa (left; axial section) and the middle fossa (right; coronal section). The postoperative facial nerve function after 1 year reached acceptable H-B grade III with synkinesis.

Case 14.13 (Left Ear)

See ▶ Fig. 14.294, ▶ Fig. 14.295, ▶ Fig. 14.296, ▶ Fig. 14.297, ▶ Fig. 14.298, ▶ Fig. 14.299, ▶ Fig. 14.300, ▶ Fig. 14.301, ▶ Fig. 14.302, ▶ Fig. 14.303, ▶ Fig. 14.304, ▶ Fig. 14.305, ▶ Fig. 14.306, ▶ Fig. 14.307, ▶ Fig. 14.308, ▶ Fig. 14.309, ▶ Fig. 14.310, ▶ Fig. 14.311, ▶ Fig. 14.312, ▶ Fig. 14.313, ▶ Fig. 14.314, ▶ Fig. 14.315, ▶ Fig. 14.316, ▶ Fig. 14.317, ▶ Fig. 14.318, ▶ Fig. 14.319, ▶ Fig. 14.320,

▶ Fig. 14.321, ▶ Fig. 14.322, ▶ Fig. 14.323, ▶ Fig. 14.324, ▶ Fig. 14.325, ▶ Fig. 14.326, ▶ Fig. 14.327, ▶ Fig. 14.328, ▶ Fig. 14.329, ▶ Fig. 14.330, ▶ Fig. 14.331, ▶ Fig. 14.332, ▶ Fig. 14.333, ▶ Fig. 14.334, ▶ Fig. 14.335, ▶ Fig. 14.336, ▶ Fig. 14.337, ▶ Fig. 14.338, ▶ Fig. 14.339, ▶ Fig. 14.340, ▶ Fig. 14.341, ▶ Fig. 14.342, ▶ Fig. 14.343, ▶ Fig. 14.344, ▶ Fig. 14.345, ▶ Fig. 14.346, ▶ Fig. 14.347, ▶ Fig. 14.348, ▶ Fig. 14.349.

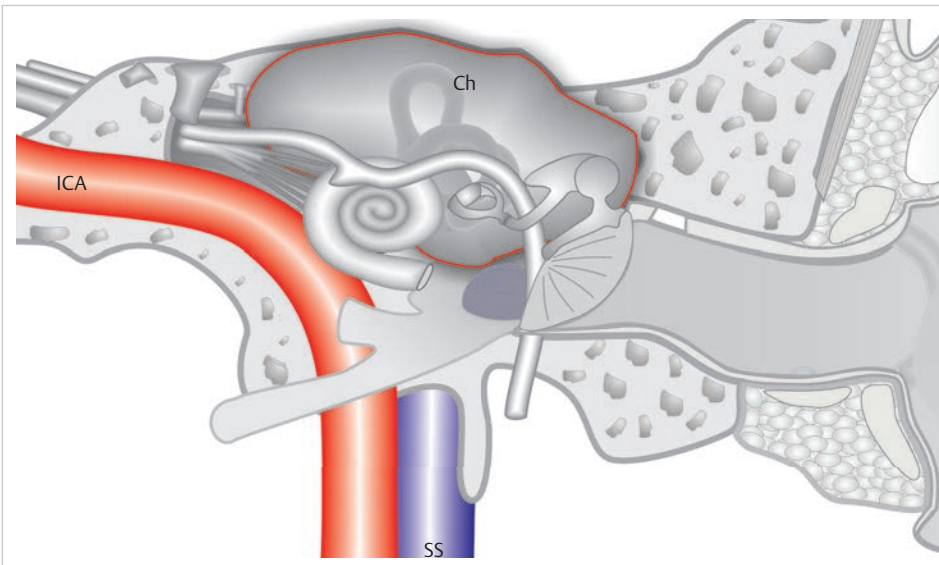


Fig. 14.294 A case of congenital supralabyrinthine petrous bone cholesteatoma extended into the internal auditory canal with erosion in both the cochlea and the posterior labyrinth removed with transotic approach with facial nerve reconstruction. Ch, cholesteatoma; ICA, internal carotid artery; SS, sigmoid sinus.



Fig. 14.295 The patient underwent middle fossa approach by a neurosurgeon for petrous bone cholesteatoma elsewhere after suffering incomplete facial palsy. Relapse of the disease in the form of complete facial palsy forced patient to have revision surgery. Preoperative otoscopy shows presence of whitish mass under the handle of the malleus (arrows). Facial palsy is graded House-Brackmann grade IV.

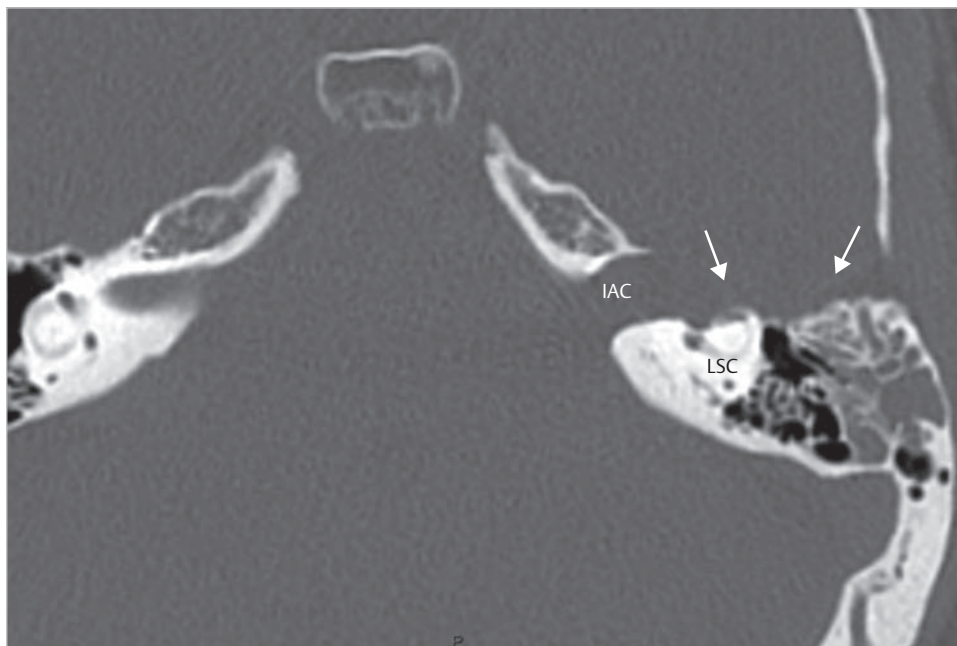


Fig. 14.296 Preoperative CT shows bone erosion in the anterior part of the pyramidal bone (*arrows*). Erosion of the lateral semicircular canal and enlargement of the internal auditory canal are identified. IAC, internal auditory canal; LSC, lateral semicircular canal.

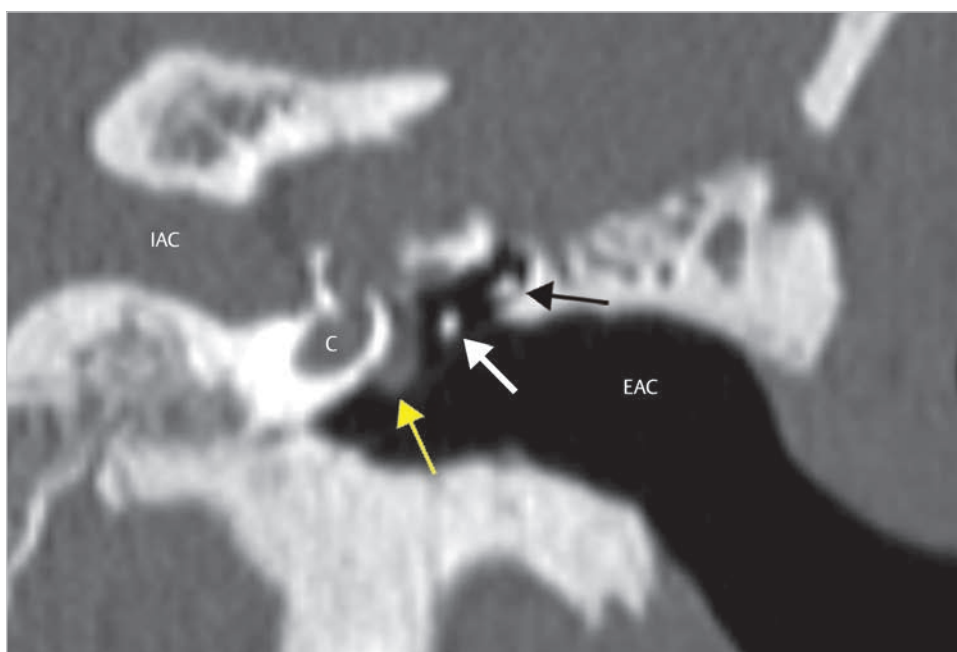


Fig. 14.297 Coronal CT at the level of the short process of the incus (*black arrow*) and the incudostapedial joint (*white arrow*) show extensive loss of bone at the level of the cochlea and the fundus of the internal auditory canal. The cholesteatoma protruding from eroded medial wall of the tympanic cavity covering the promontory is seen (*yellow arrow*). A bone flap replaced over the middle fossa is identified (*black arrow*). C, cochlea; EAC, external auditory canal; IAC, internal auditory canal.

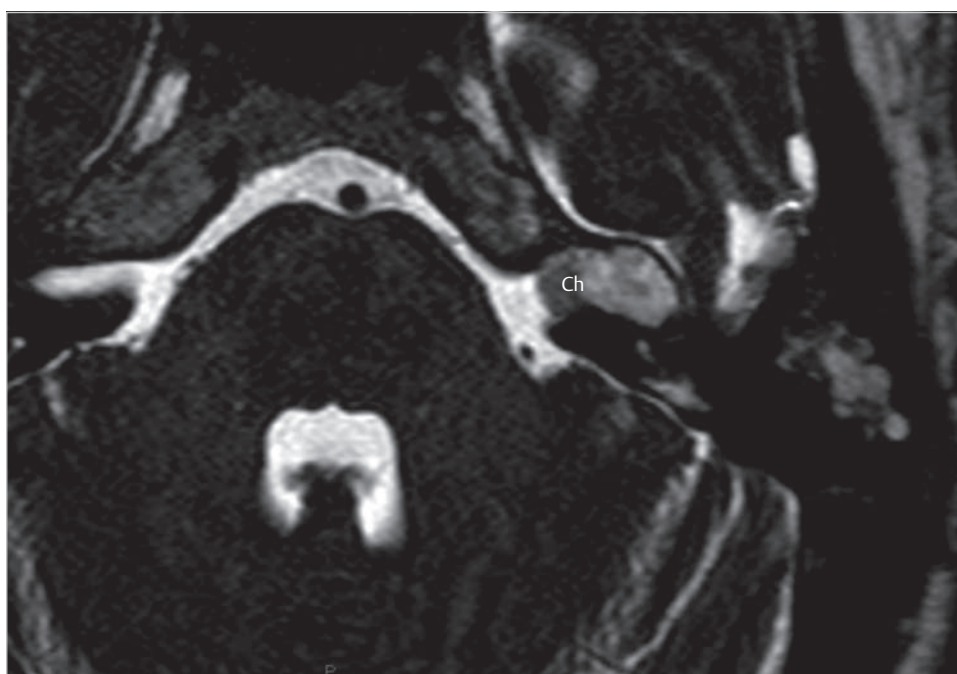


Fig. 14.298 The axial section of heavy T2-weighted MRI clearly demonstrates extension of the cholesteatoma into the internal auditory canal. Ch, cholesteatoma.

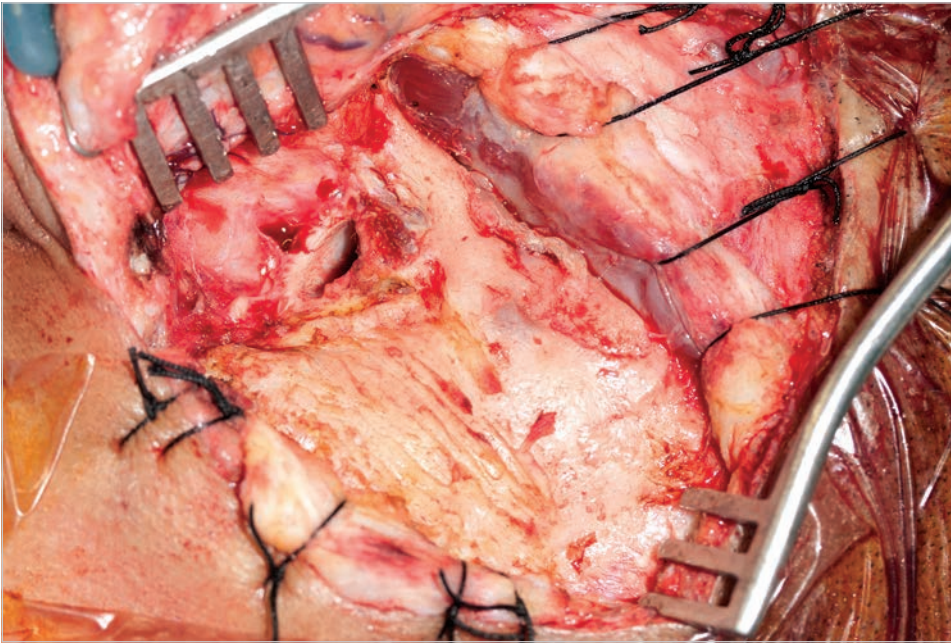


Fig. 14.299 Preparation for petrous bone cholesteatoma surgery is shown. To obtain sufficient access to the petrous apex, it requires wide exposure of the lateral surface of the skull, including anterosuperior part of the occipital bone, and anteroinferior part of the parietal bone. Note the difference from common middle ear surgeries.

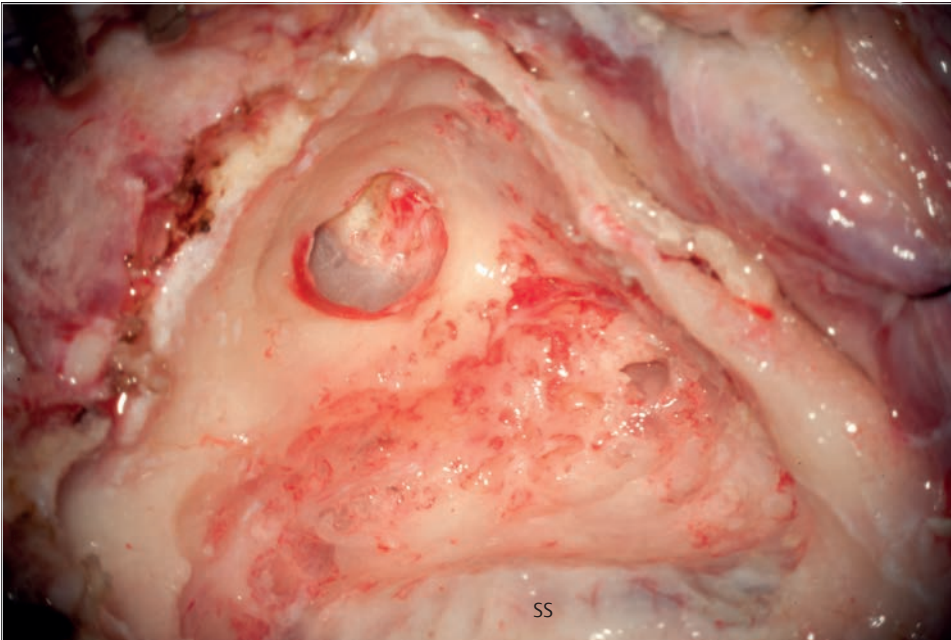


Fig. 14.300 Canal wall down mastoidectomy is carried out. The posterior wall of the bony meatus is partially removed. No cholesteatoma is seen in the mastoid. SS, sigmoid sinus.

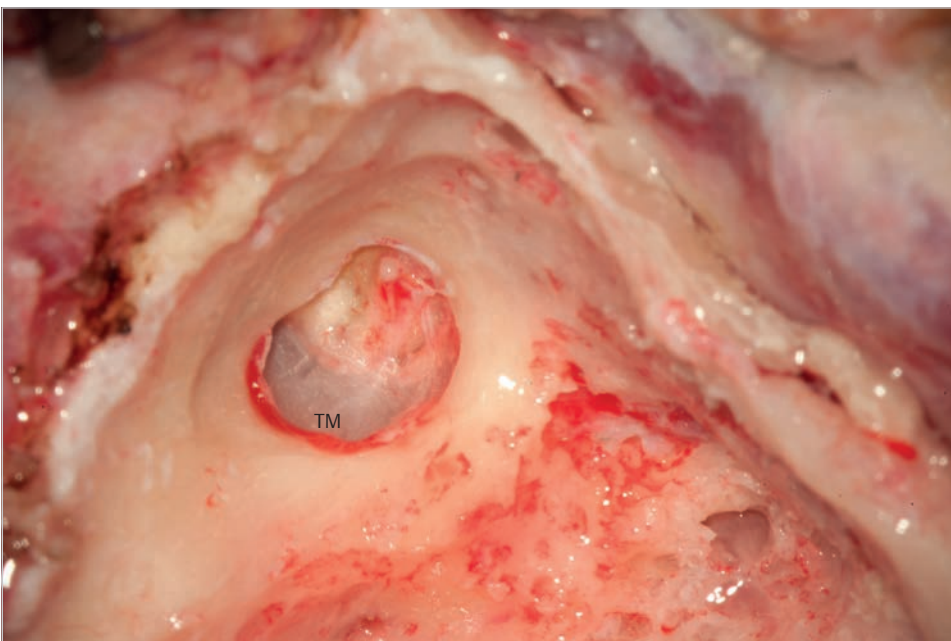


Fig. 14.301 A whitish mass is seen behind the intact tympanic membrane suggesting congenital nature of the cholesteatoma. TM, tympanic membrane.

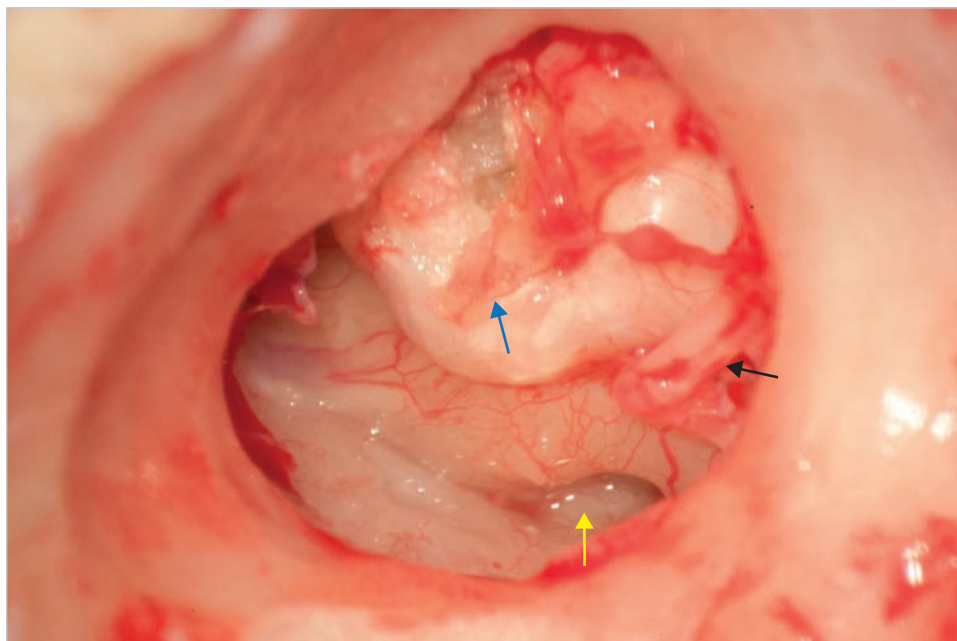


Fig. 14.302 The tympanomeatal flap is totally removed to open the tympanic cavity. The cholesteatoma is seen under the handle of the malleus (*blue arrow*). The long process of the incus (*black arrow*) and the round window niche (*yellow arrow*) are visualized.

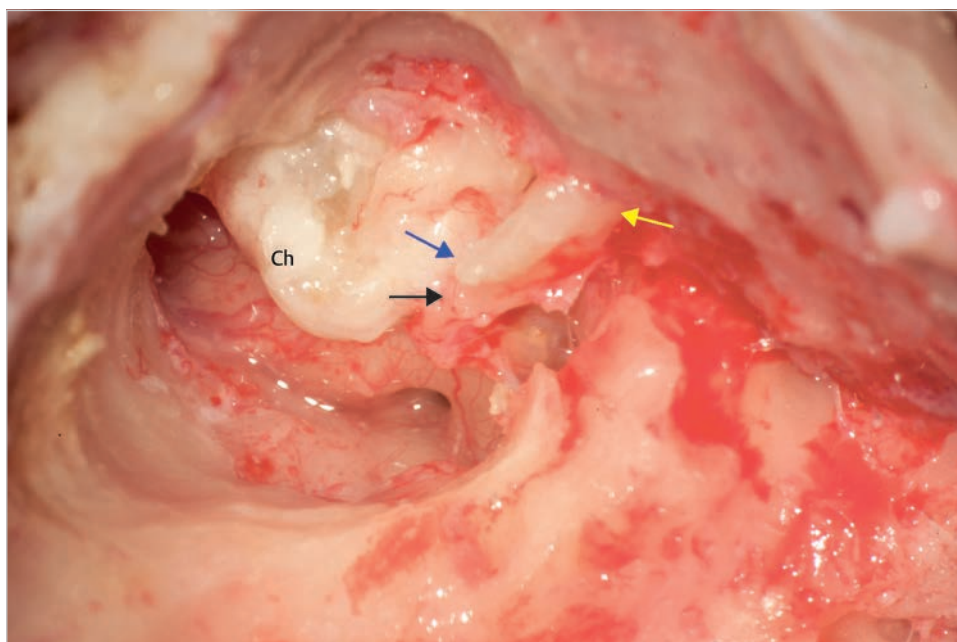


Fig. 14.303 The posterior wall of the meatus is removed, and the attic is partially opened. The incus (*blue arrow*; short process, *yellow arrow*; body, *black arrow*; long process) is dislocated totally as a result of a mistake in the former surgery. Ch, cholesteatoma.

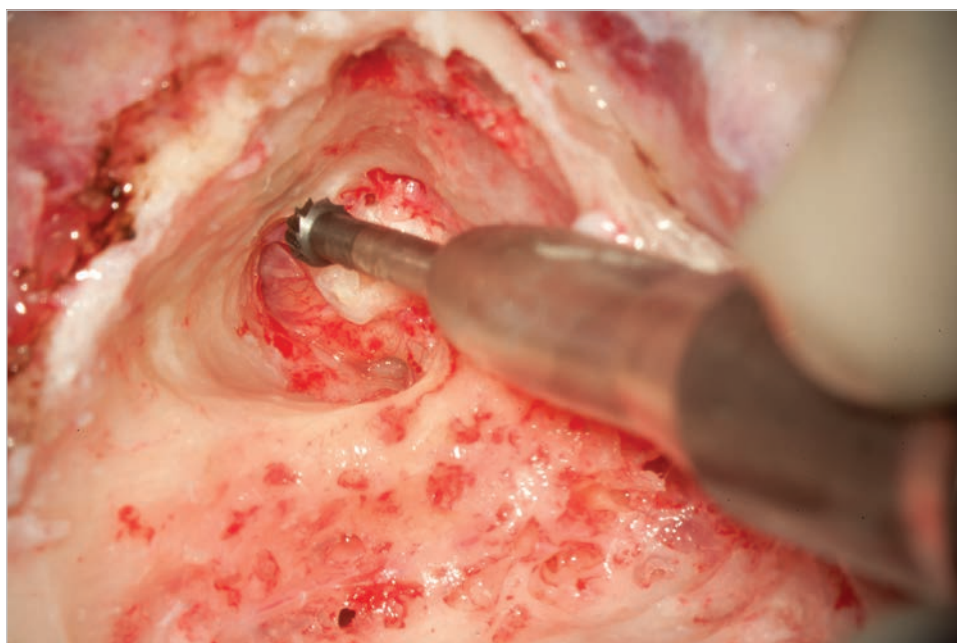


Fig. 14.304 The drilling of the attic is advanced anteriorly to open the supratubal recess.

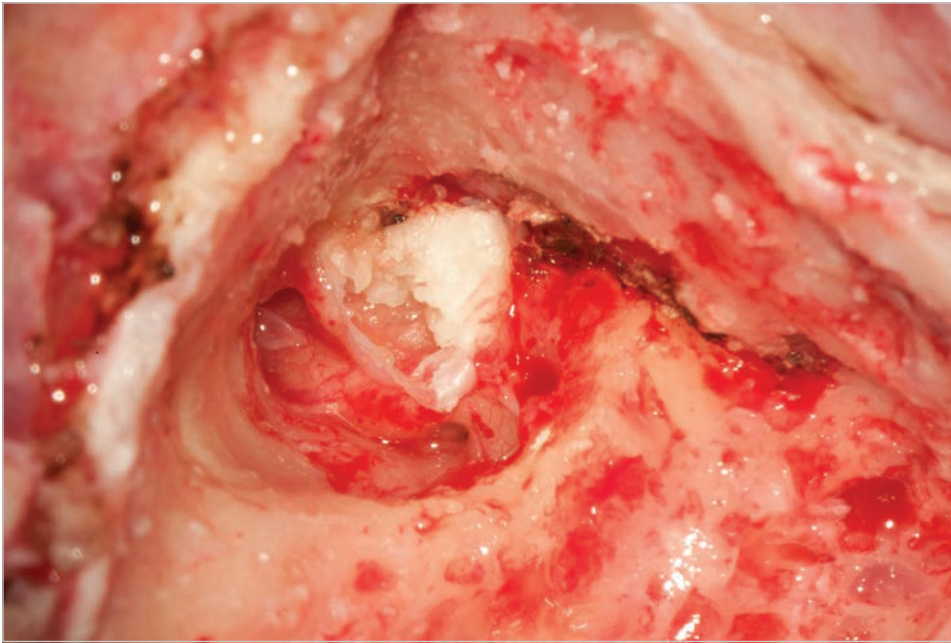


Fig. 14.305 The cholesteatoma eroding the medial wall of the mesotympanum and the attic is shown.

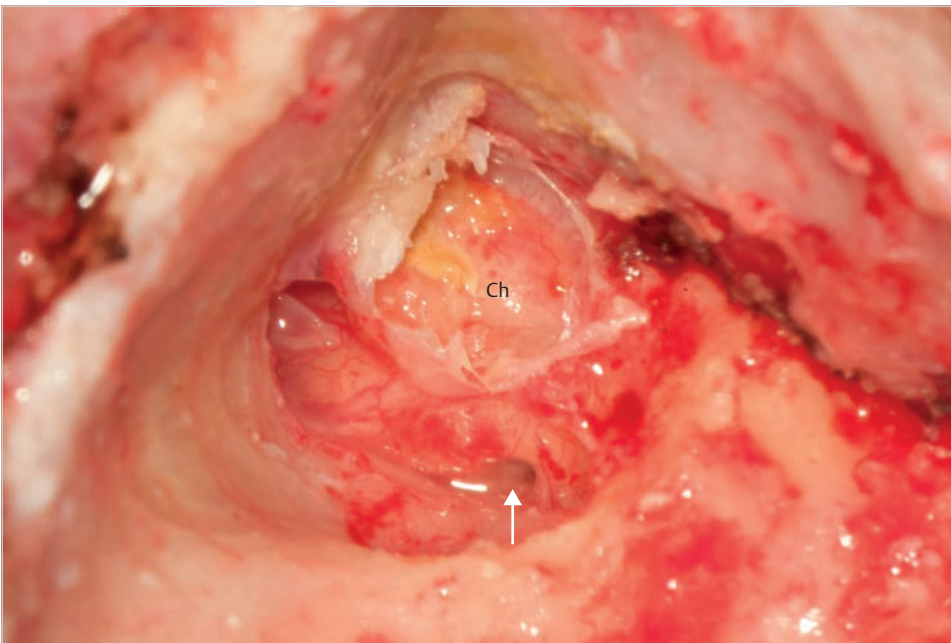


Fig. 14.306 Debris filling the cholesteatoma is partially removed. Thin matrix covering the medial wall eroding the promontory anterior to the round window (*arrow*) is seen. Ch, cholesteatoma.

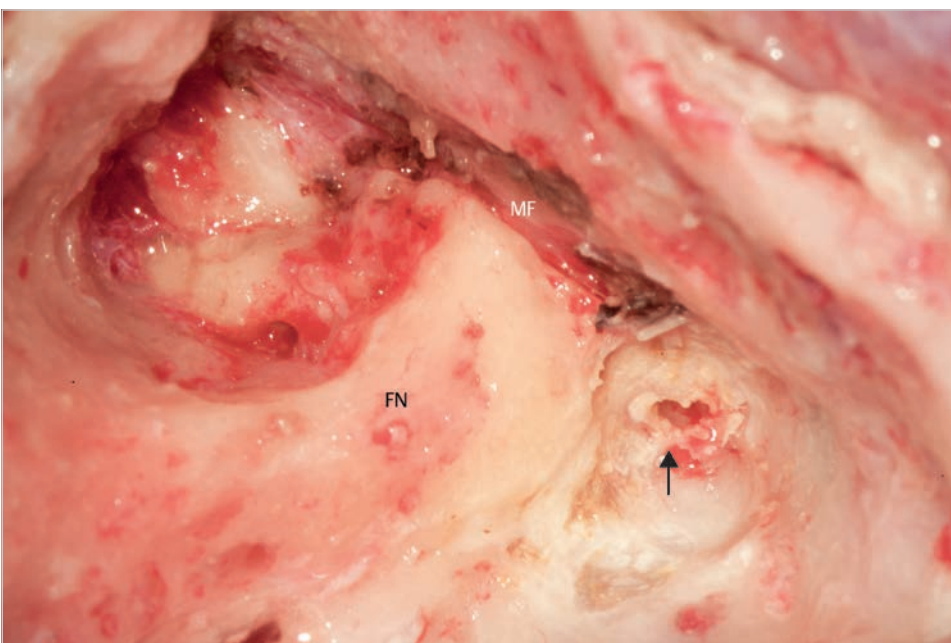


Fig. 14.307 The matrix is removed from the medial wall of the tympanic cavity. Drilling of the semicircular canals revealed extensive ossification of the labyrinth. Cholesteatoma is started to be exposed (*arrow*) in the perilyabyrinthine cells within the superior semicircular canal. As seen, the middle fossa plate in the tegmen of the attic has been removed in the former surgery. FN, facial nerve; MF, middle fossa dura.

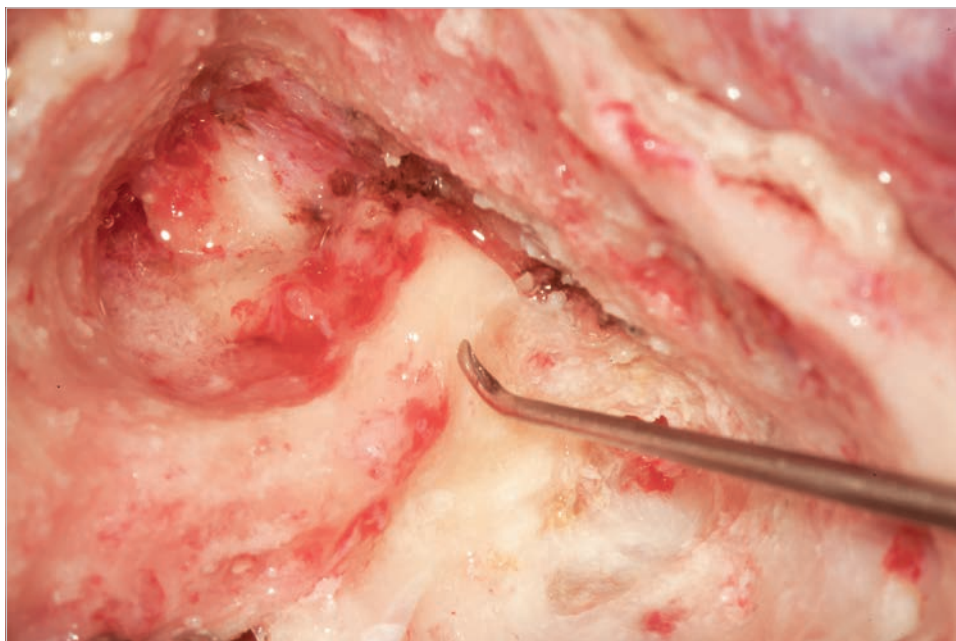


Fig. 14.308 The completely ossified lateral semicircular canal is pointed with the instrument.

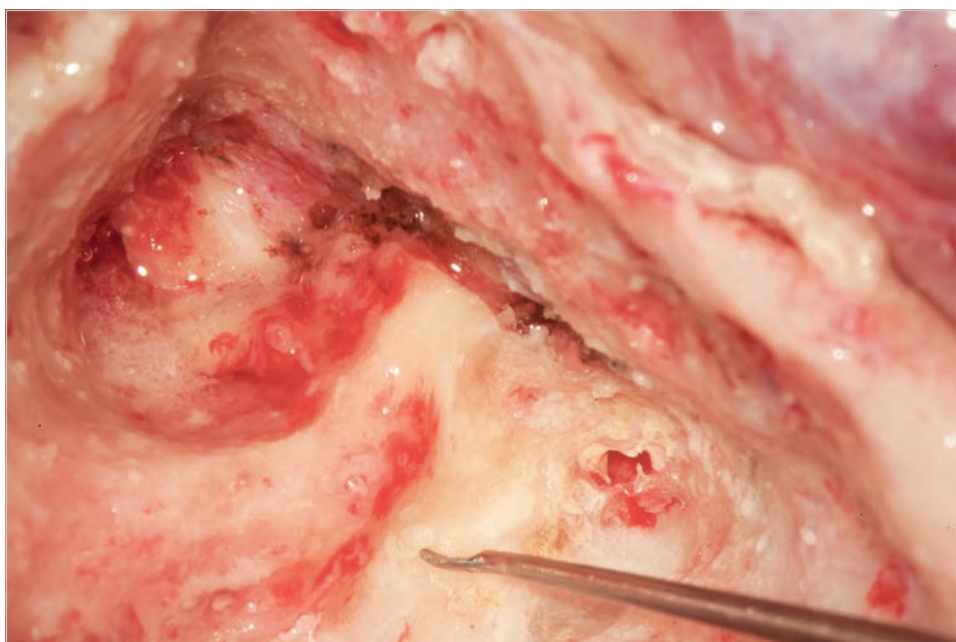


Fig. 14.309 The instrument points the completely ossified posterior semicircular canal.

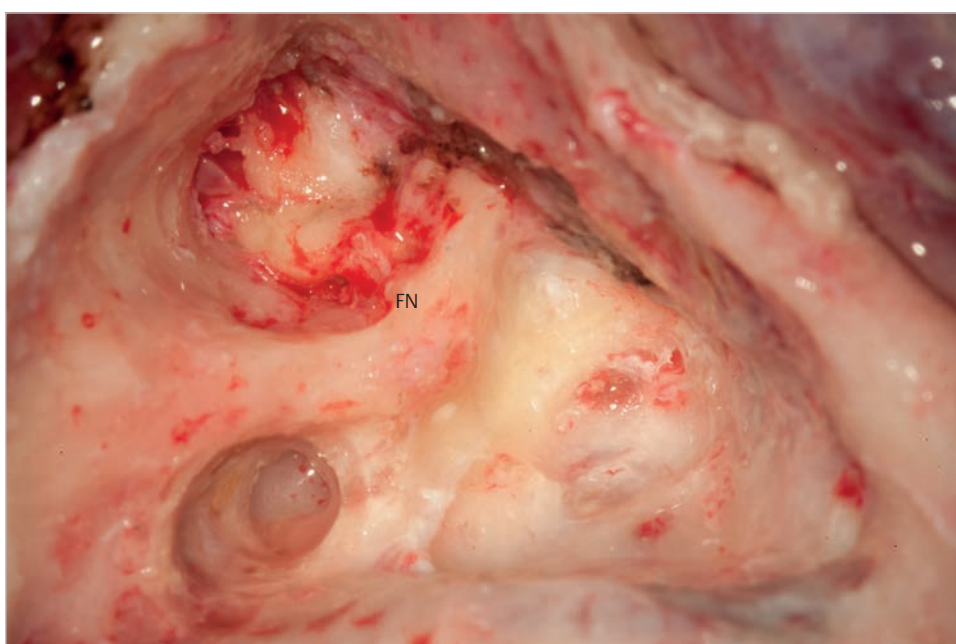


Fig. 14.310 Subfacial tympanotomy to remove the cholesteatoma in hypotympanic cells are carried out, and the cholesteatoma is completely removed. Note the wide opening of the subfacial area connected to the hypotympanum. FN, facial nerve.

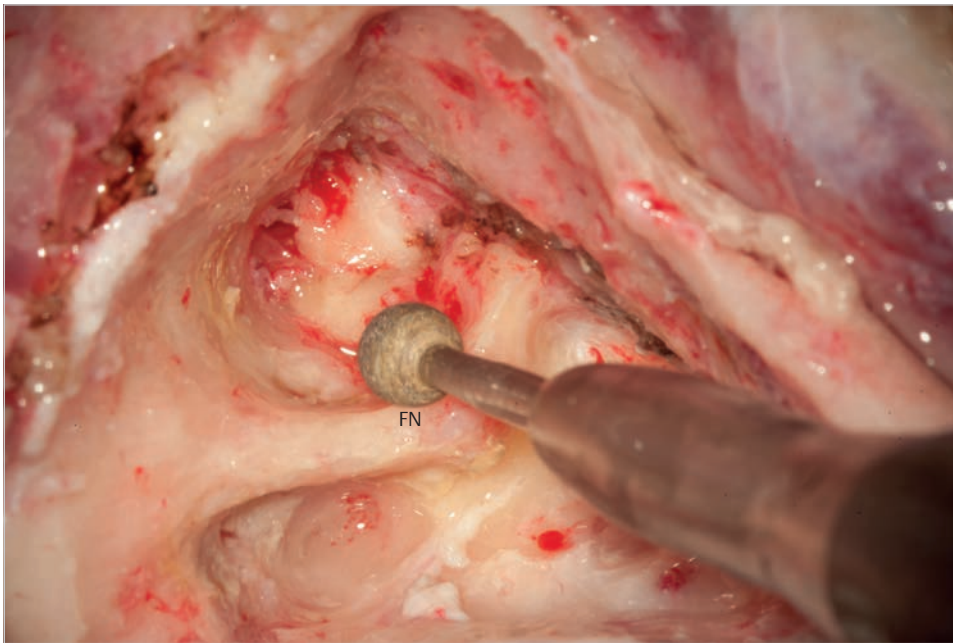


Fig. 14.311 The bone covering the facial nerve is thinned with a large diamond burr. FN, facial nerve.

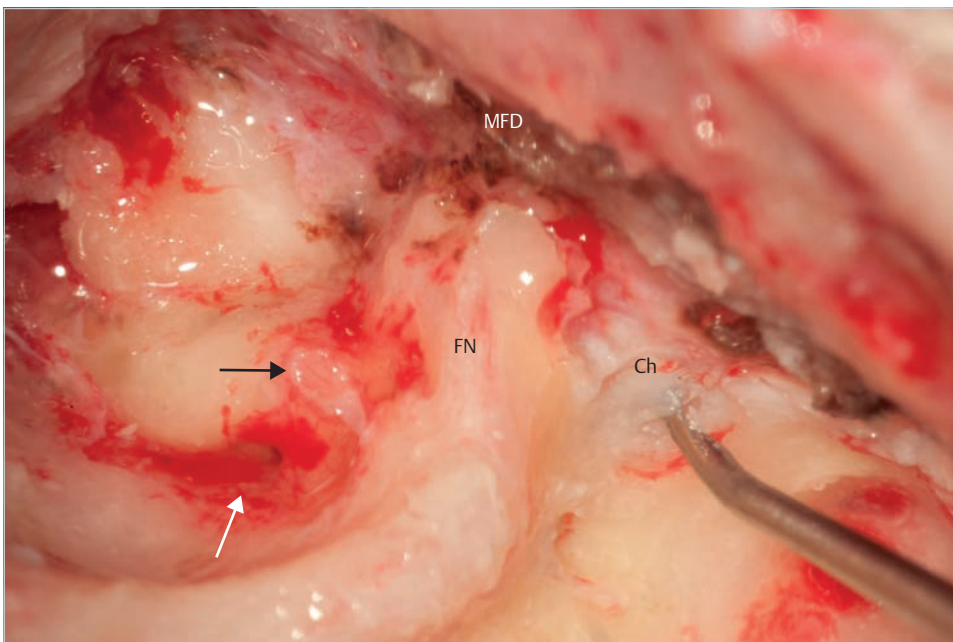


Fig. 14.312 The drilling is advanced anteriorly to remove the medial wall of the attic. The matrix of the cholesteatoma goes deeply along the middle fossa dura. The stapes (*black arrow*) is seen between the facial nerve and the round window niche (*white arrow*). Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura.

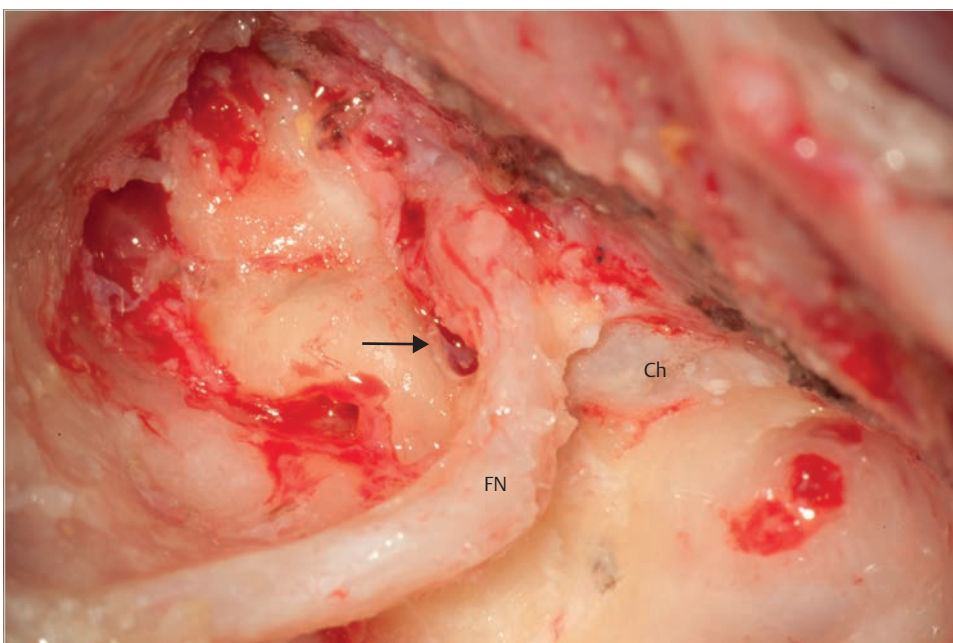


Fig. 14.313 The tympanic segment of the facial nerve is exposed. Note the swelling of the nerve superiorly to the oval window (*arrow*). Ch, cholesteatoma; FN, facial nerve.

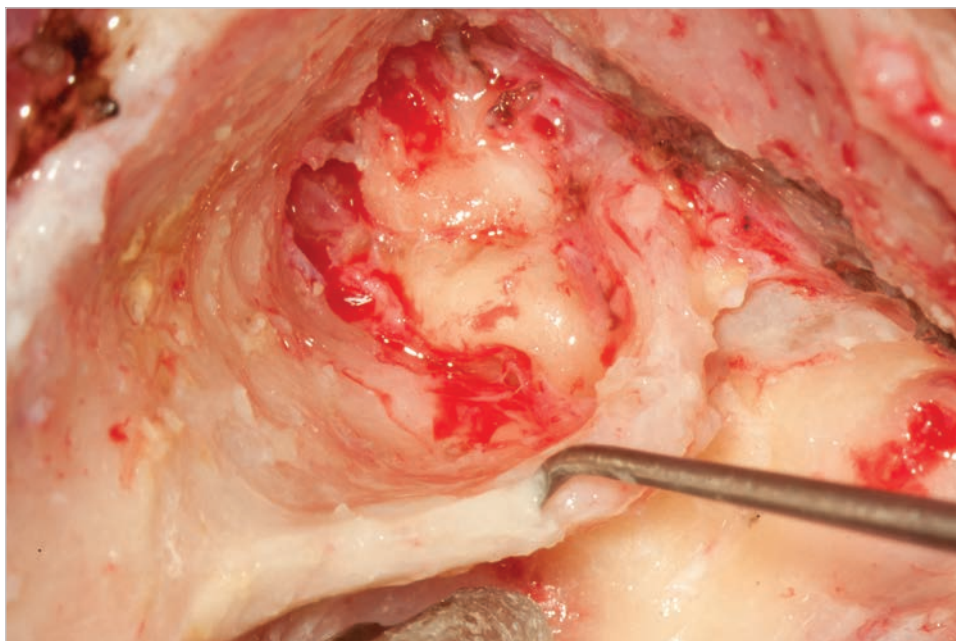


Fig. 14.314 Exposure of the mastoid segment of the facial nerve by removing thin bony shell is carried out.

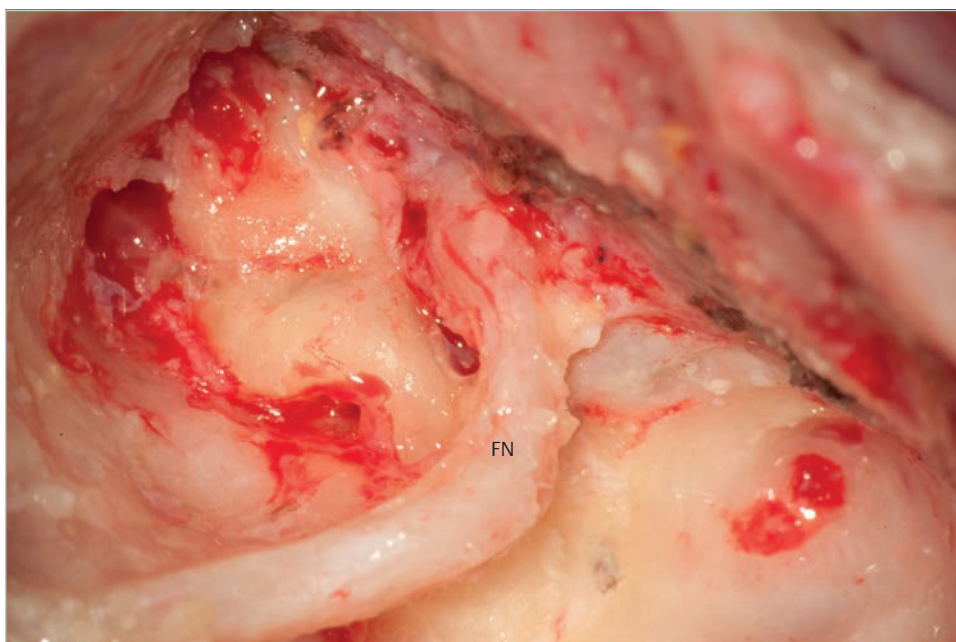


Fig. 14.315 The facial nerve is exposed from the great superficial petrosal nerve to the mastoid segment. FN, facial nerve.

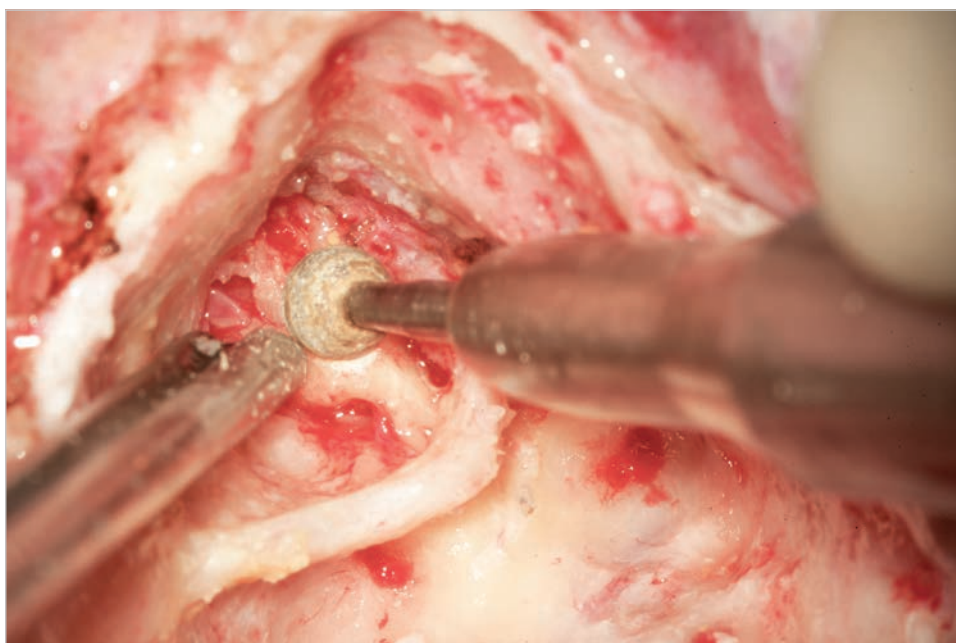


Fig. 14.316 The cochlea is drilled with a large diamond burr.

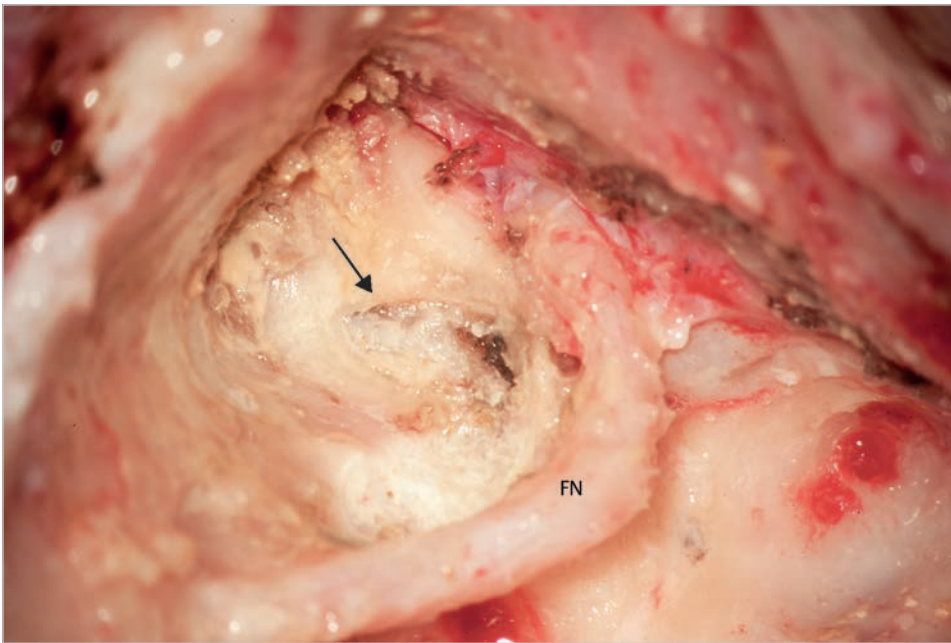


Fig. 14.317 The basal turn of the cochlea filled with fibrous tissue is opened (*arrow*). FN, facial nerve.

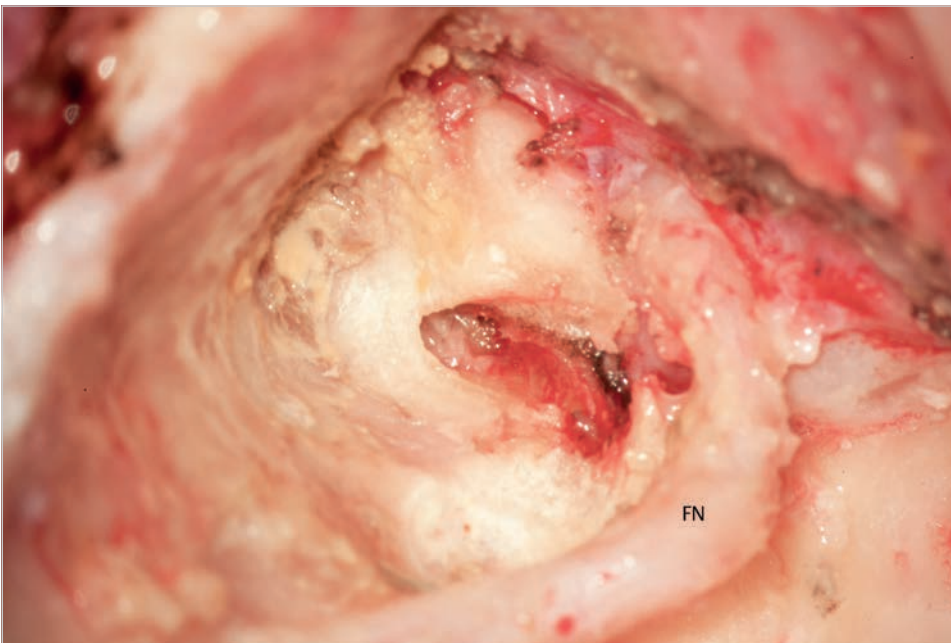


Fig. 14.318 The fibrous tissue filling the basal turn is removed to show the lumen of the turn. FN, facial nerve.

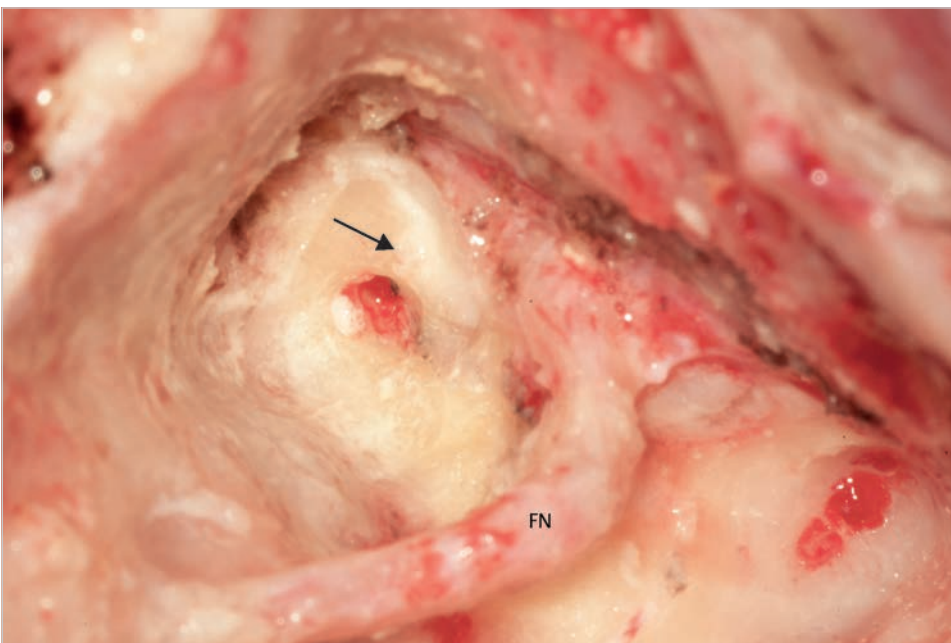


Fig. 14.319 Drilling of the cochlea is advanced superiorly. Complete occlusion of apical two turns with ossification is shown (*arrow*). FN, facial nerve.



Fig. 14.320 The bone lateral to the formerly exposed middle fossa dura is removed to gain access to the petrous apes. The dura suspicious of residual matrix should be carefully coagulated with bipolar. Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura.

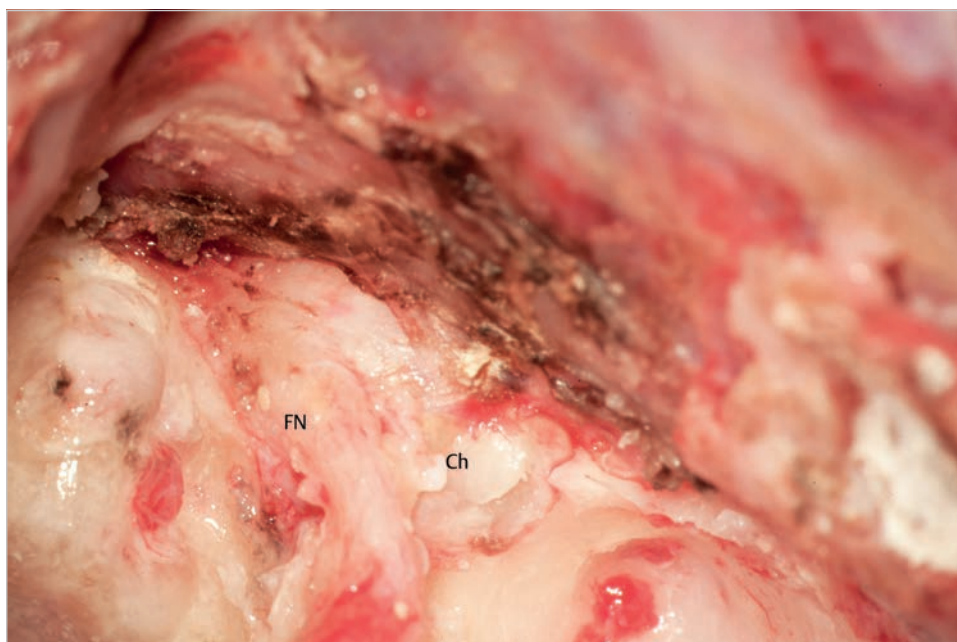


Fig. 14.321 A massive cholesteatoma occupying the area superomedially to the geniculate ganglion is shown. Ch, cholesteatoma; FN, facial nerve.

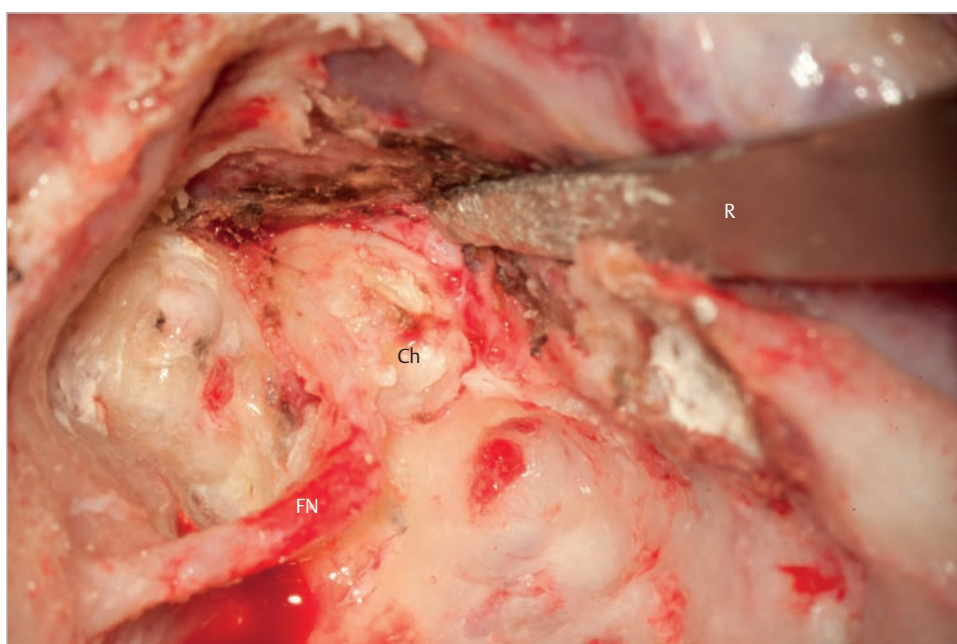


Fig. 14.322 A retractor for the middle fossa approach is applied to maintain good access to the cholesteatoma occupying the supralabyrinthine area. Ch, cholesteatoma; FN, facial nerve; R, retractor.

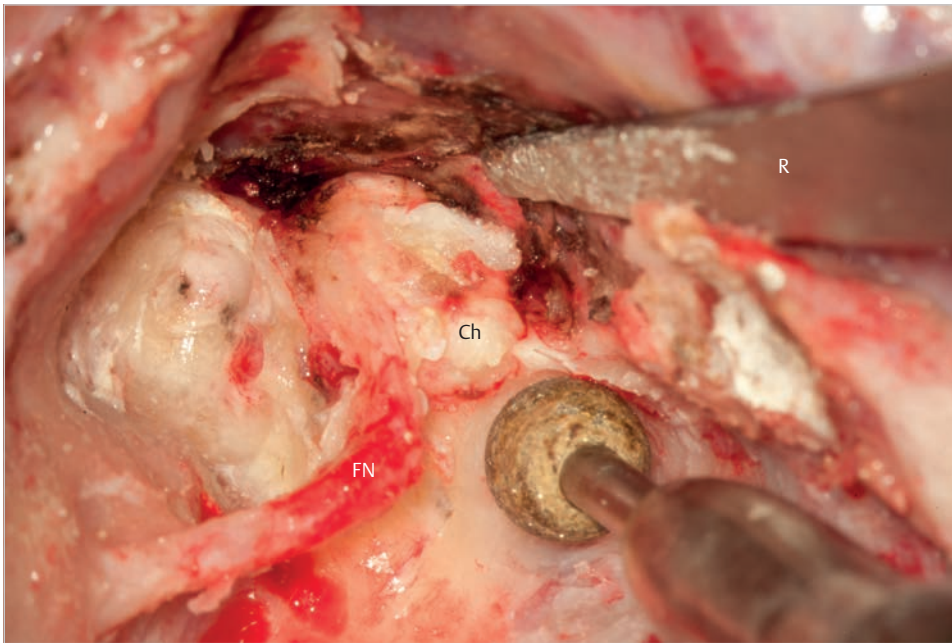


Fig. 14.323 Removal of the bone from the area superiorly to the internal auditory canal is conducted with a large diamond burr. Ch, cholesteatoma; FN, facial nerve; R, middle fossa retractor.

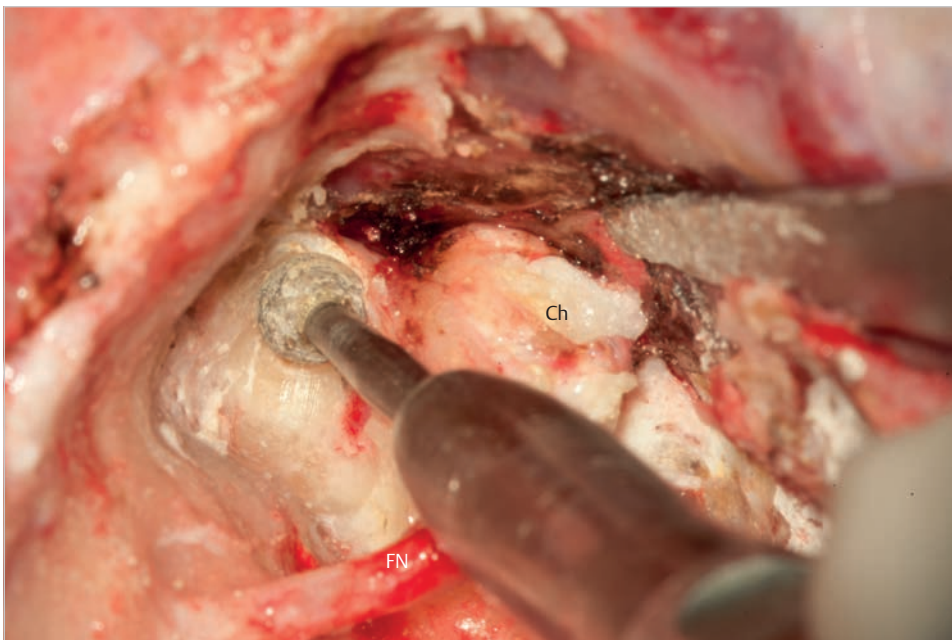


Fig. 14.324 Drilling of the ossified cochlea is carried out. Ch, cholesteatoma; FN, facial nerve.

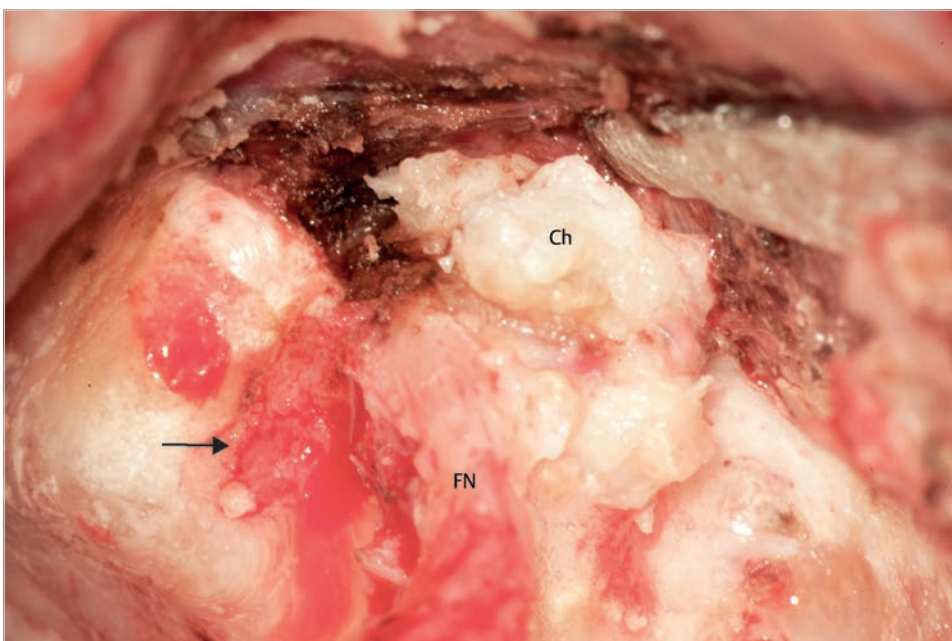


Fig. 14.325 Granulation tissue covering the cholesteatoma filling the area of the cochlea near the fundus is exposed (arrow) inferiorly to the facial nerve. Ch, cholesteatoma; FN, facial nerve.

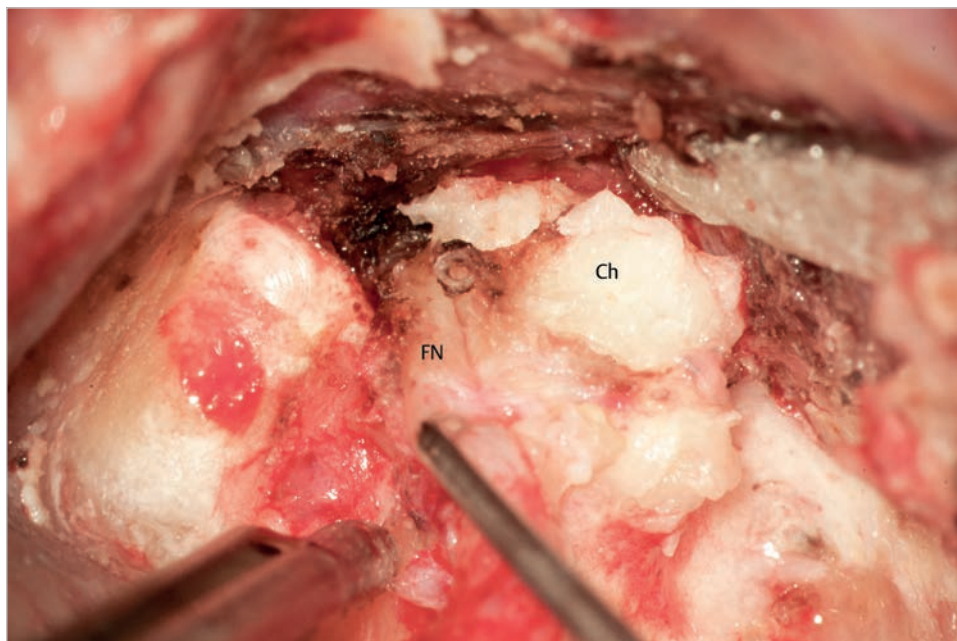


Fig. 14.326 The massive cholesteatoma passes under the facial nerve is shown. Ch, cholesteatoma; FN, facial nerve.

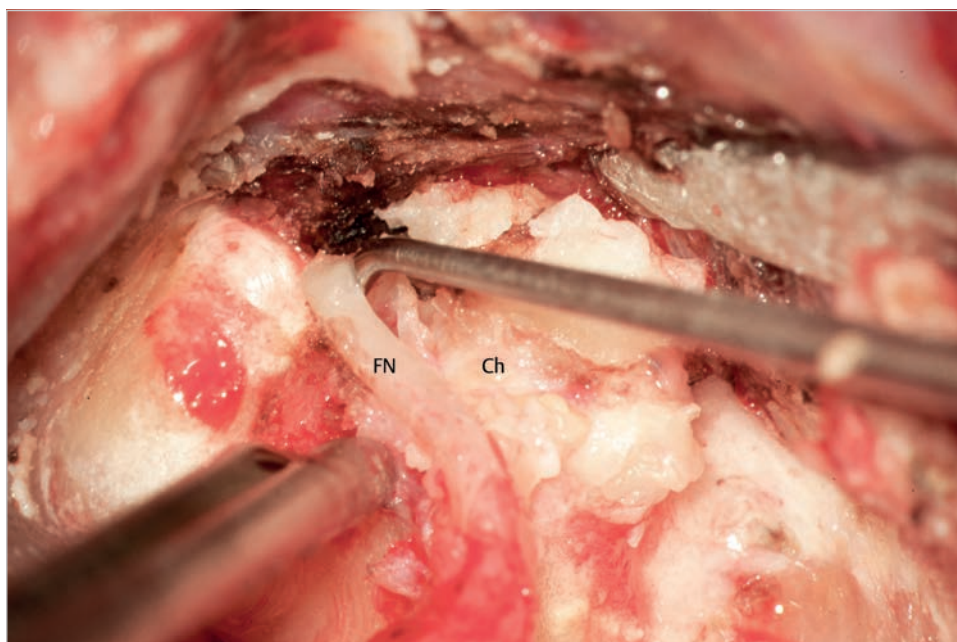


Fig. 14.327 To evaluate the damage of the facial nerve, the nerve is carefully elevated from the fallopian canal with the microdissector. Ch, cholesteatoma; FN, facial nerve.

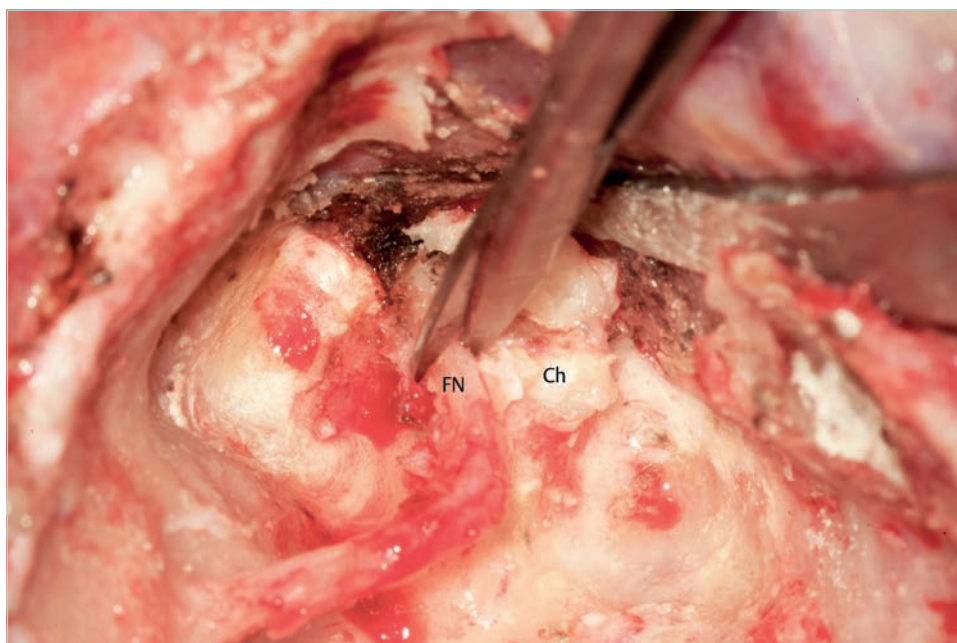


Fig. 14.328 Since the facial nerve is scarred around the geniculate ganglion, a repair with nerve grafting is indicated. The facial nerve is transected at the level of the tympanic segment just superior to the stapes. Ch, cholesteatoma; FN, facial nerve.

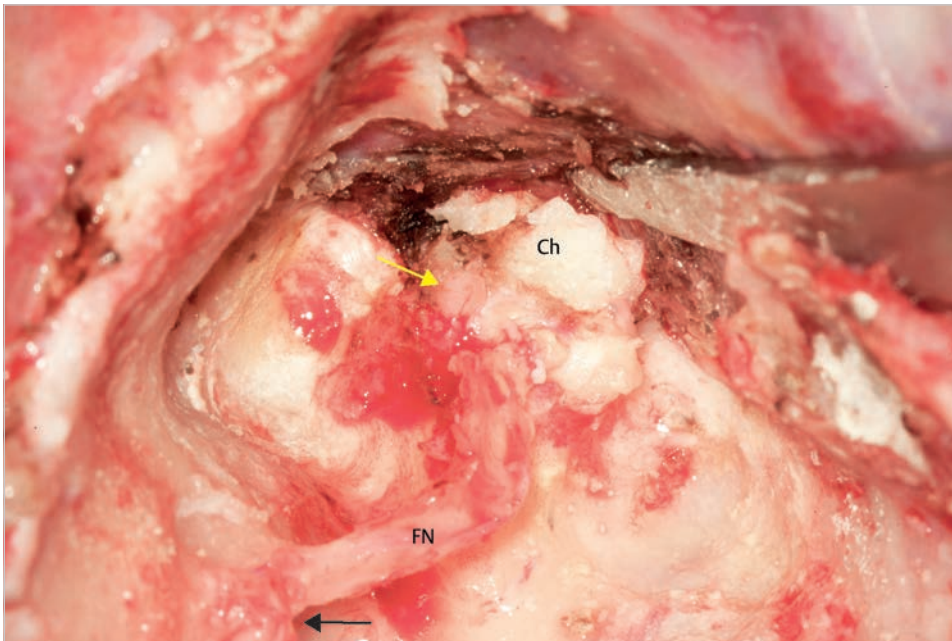


Fig. 14.329 The distal portion of the nerve (*yellow arrow*) is detached from the fallopian canal and reflected posteriorly. The proximal end of the nerve (*black arrow*) is still in place. Ch, cholesteatoma; FN, facial nerve.

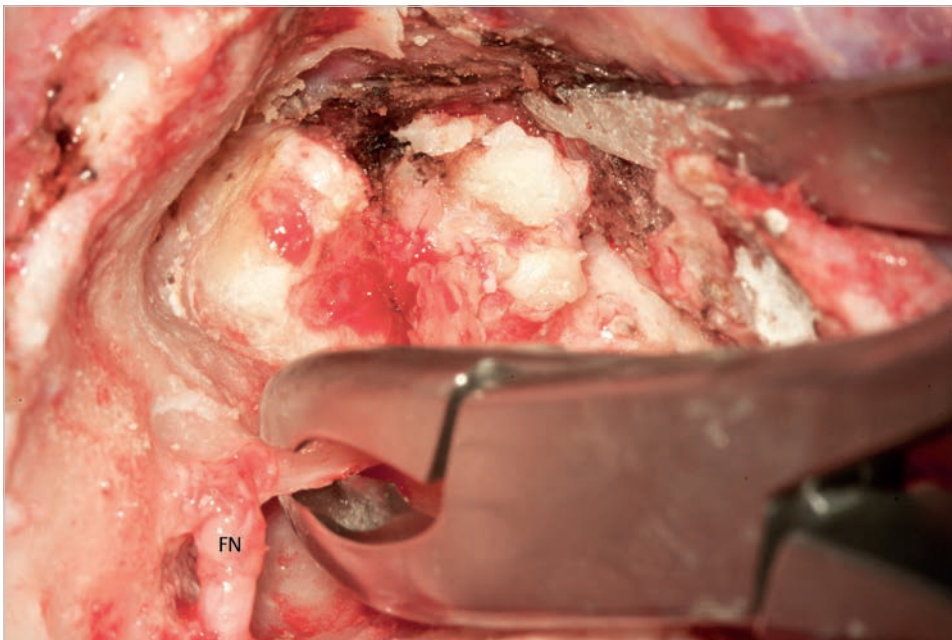


Fig. 14.330 The bone under the fallopian canal is removed with a rongeur. FN, facial nerve.

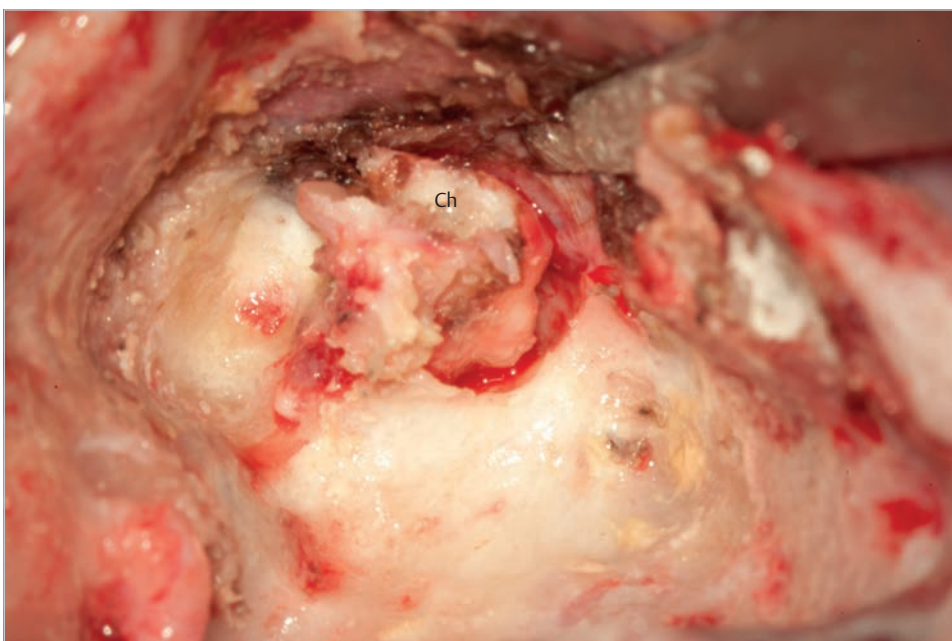


Fig. 14.331 Transection of the facial nerve and removal of the bone under the nerve create wide access to the cholesteatoma. Dissection of cholesteatoma from the middle fossa dura is advanced medially. Ch, cholesteatoma.

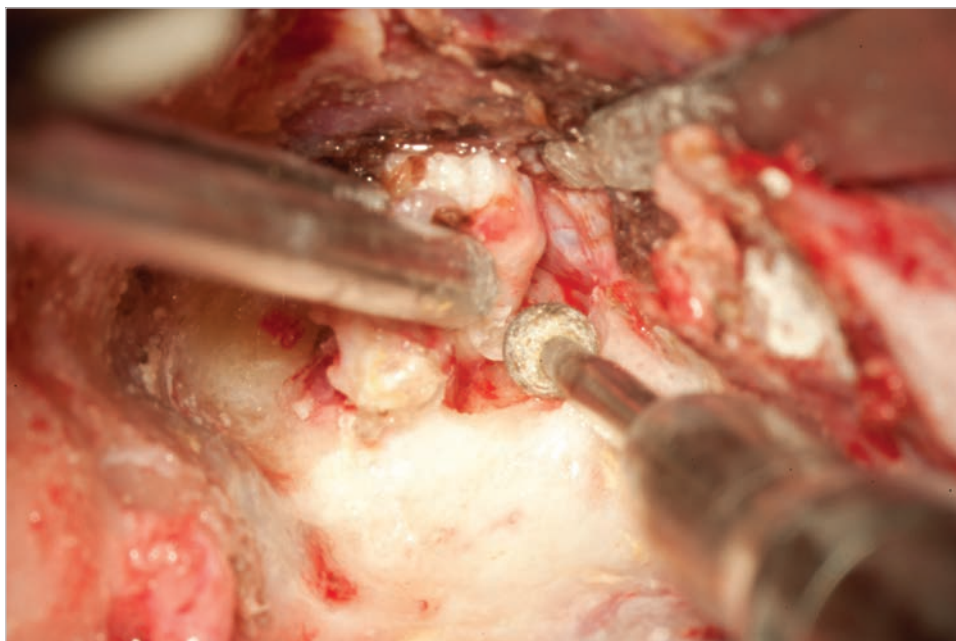


Fig. 14.332 The bone impeding access to the cholesteatoma is removed, and the contents of the internal auditory canal is started to be exposed.

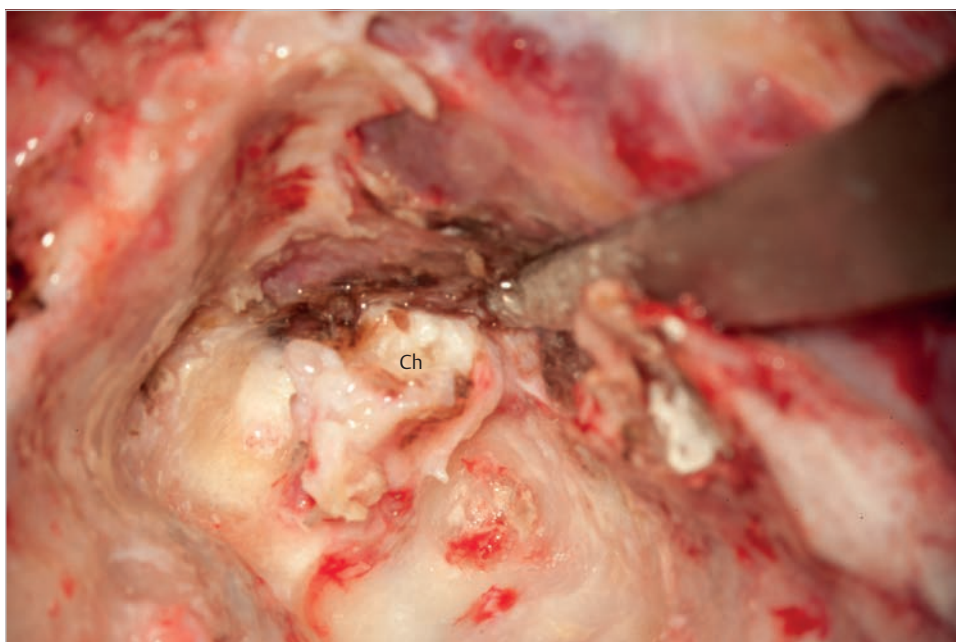


Fig. 14.333 The matrix and granulation tissue covering the internal auditory canal is shown. Ch, cholesteatoma.



Fig. 14.334 The middle fossa dura needs to be coagulated intensively due to intimate attachment of cholesteatoma matrix. Ch, cholesteatoma.

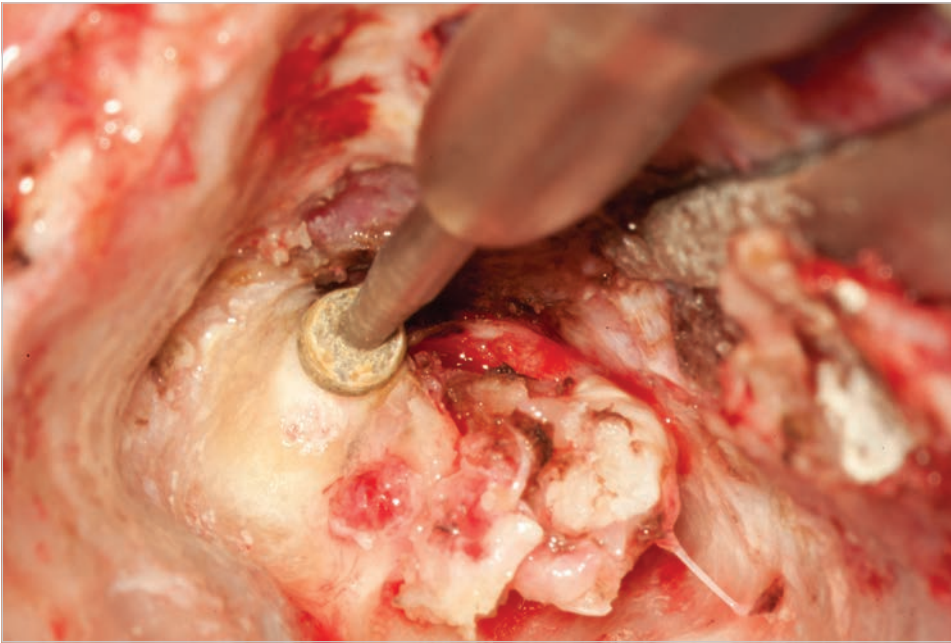


Fig. 14.335 The bone anterior to the internal auditory canal is removed to expose the most medial part of the cholesteatoma.

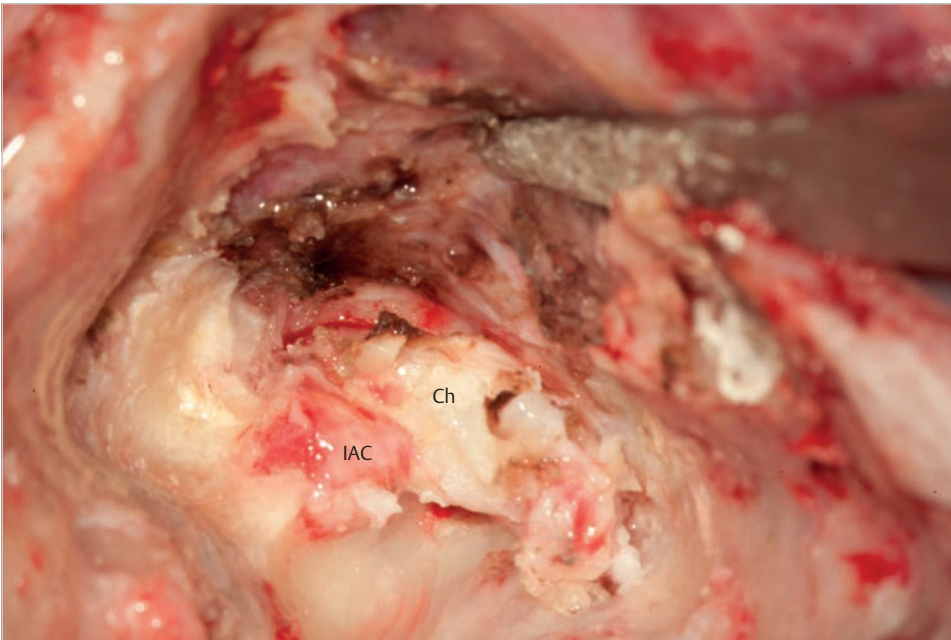


Fig. 14.336 The drilling exposed cholesteatoma eroding the superior face of the internal auditory canal and invaginating into it is shown. Ch, cholesteatoma; IAC, internal auditory canal with nerves.

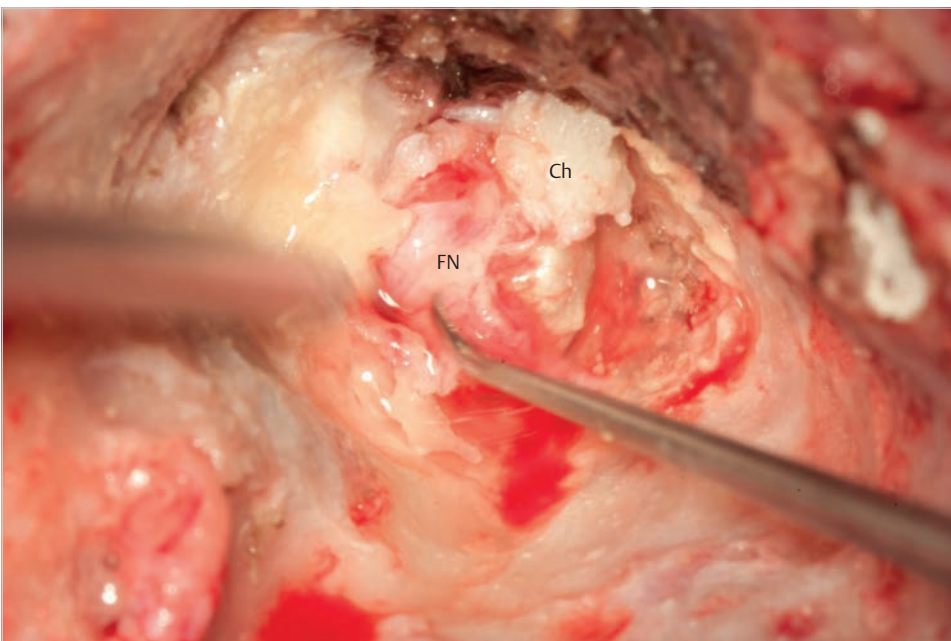


Fig. 14.337 The inferior aspect of the internal auditory canal covered with periosteum is detached from the bony wall. Note the cholesteatoma inside the internal auditory canal compressing the contents of it. Ch, cholesteatoma; FN, facial nerve.

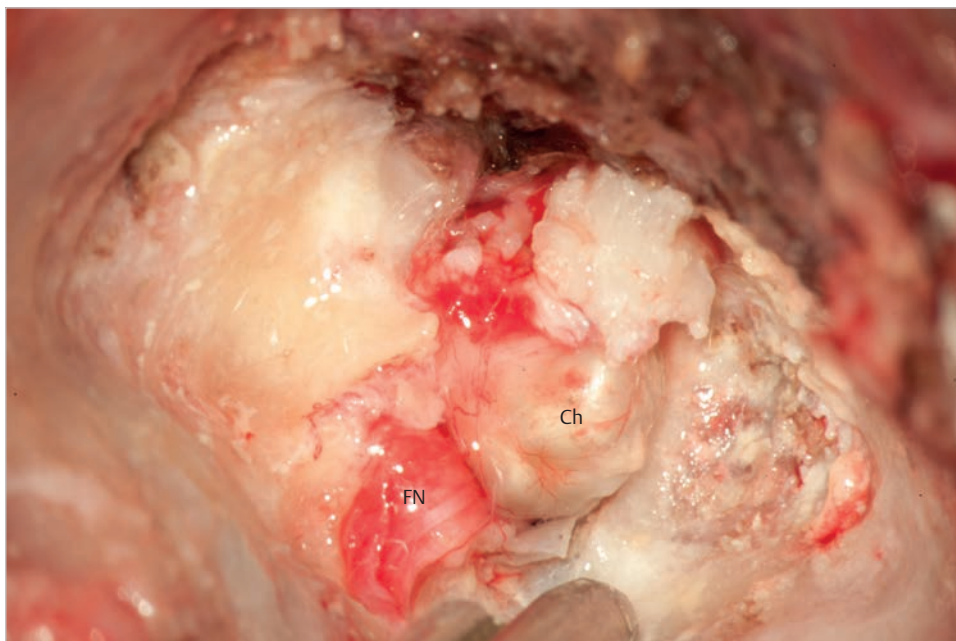


Fig. 14.338 The most medial part of the cholesteatoma invaginating into the internal auditory canal is exposed. The lumpy glazing and whitish appearance are characteristics of intradural component of the cholesteatoma, or epidermoid cyst of the cerebellopontine angle. Ch, cholesteatoma; FN, facial nerve.

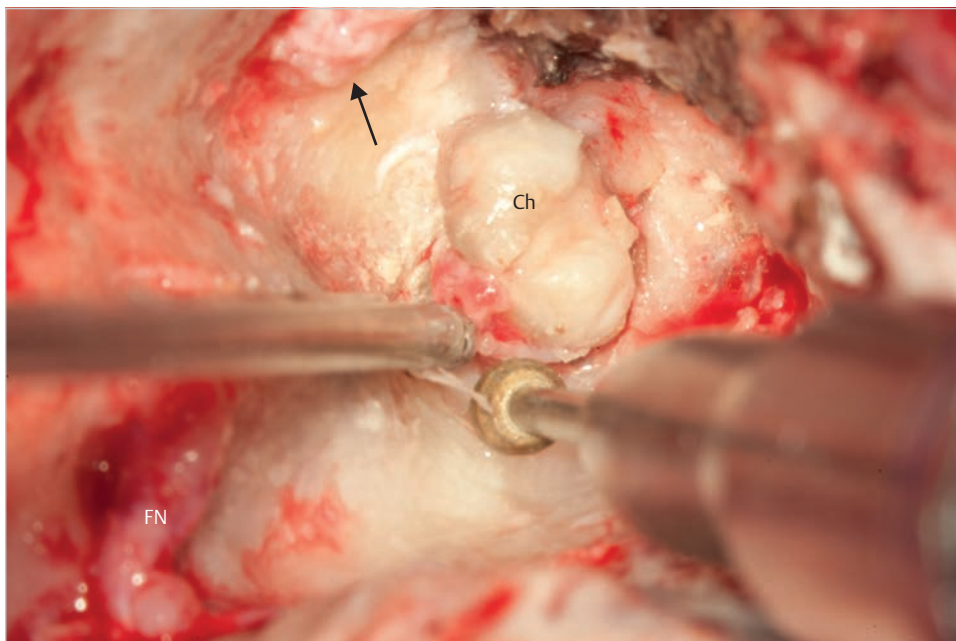


Fig. 14.339 After closing the eustachian tube with pieces of connective tissue (*arrow*), a groove for a new fallopian canal to accommodate the reanimated facial nerve is created with a diamond burr. The most medial part of the cholesteatoma is left in place to avoid bone dust falling down to the cerebellopontine angle. Ch, cholesteatoma; FN, facial nerve, distal portion.

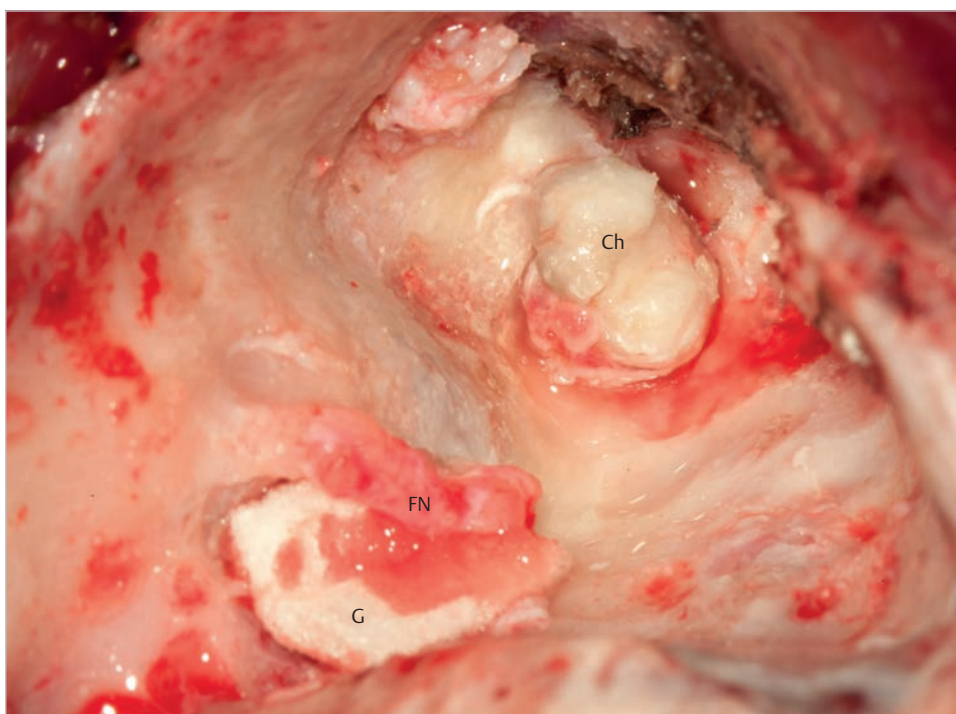


Fig. 14.340 The distal portion of the facial nerve is secured with a large piece of Gelfoam. Ch, cholesteatoma; FN, facial nerve; G, Gelfoam.

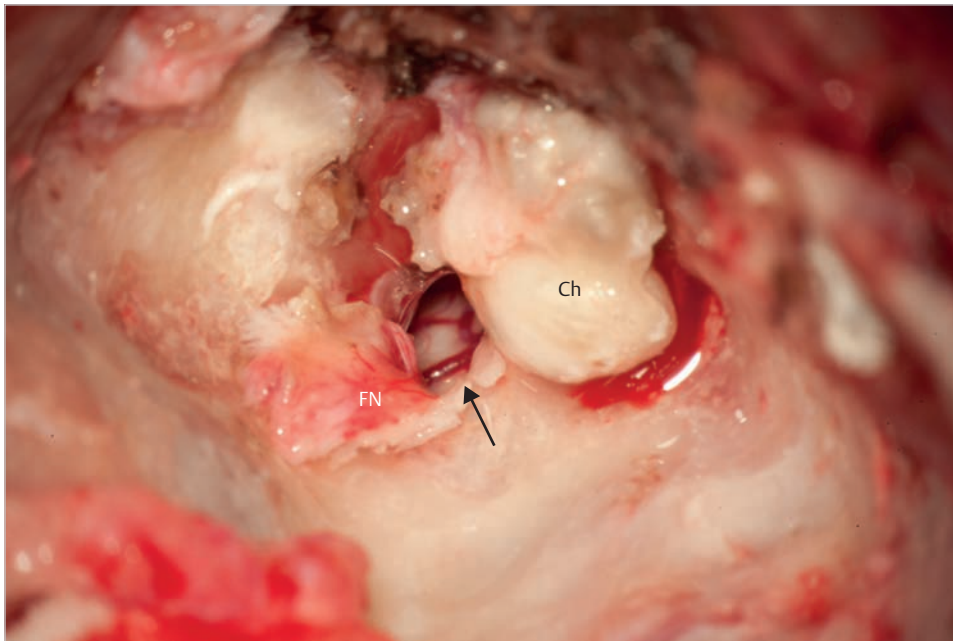


Fig. 14.341 The last part of cholesteatoma is dissected from the internal auditory canal. The cerebellopontine angle is seen (*arrow*) through the porus of the internal auditory canal. Ch, cholesteatoma; FN, facial nerve.

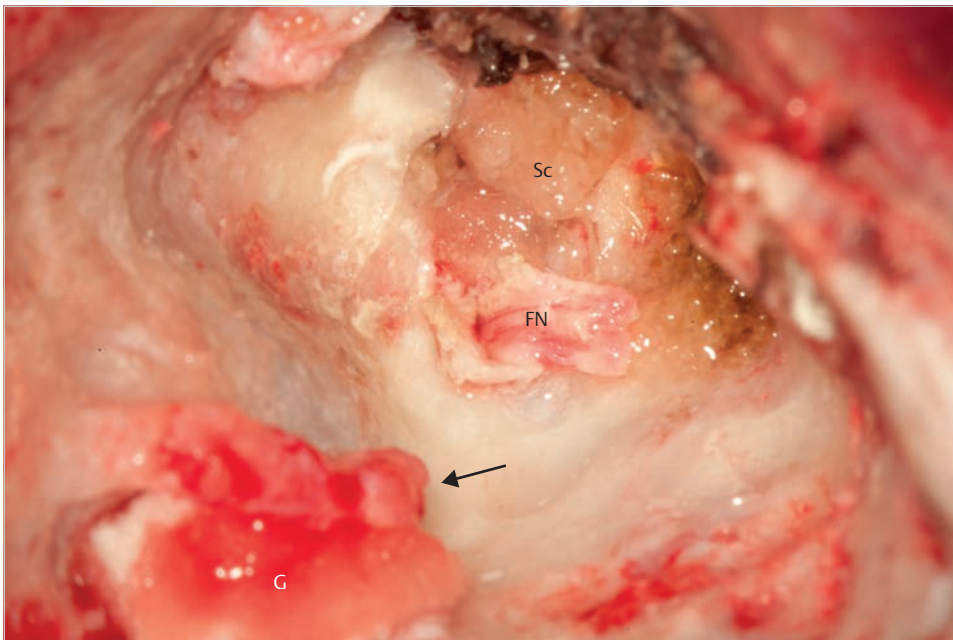


Fig. 14.342 The cholesteatoma is totally removed. The position of the facial nerve is secured by gently packing the porus of the internal auditory canal with periosteum to secure position of the proximal end of the facial nerve (*arrow*), not to fall down into the cerebellopontine (CP) angle. The distal stump of the facial nerve is refreshed, and ready for reconstruction (*arrow*). FN, facial nerve; G, Gelfoam; Sc, Surgicel.



Fig. 14.343 Enlarged view. The proximal stump of the facial nerve is shown. FN, facial nerve; Sc, Surgicel.

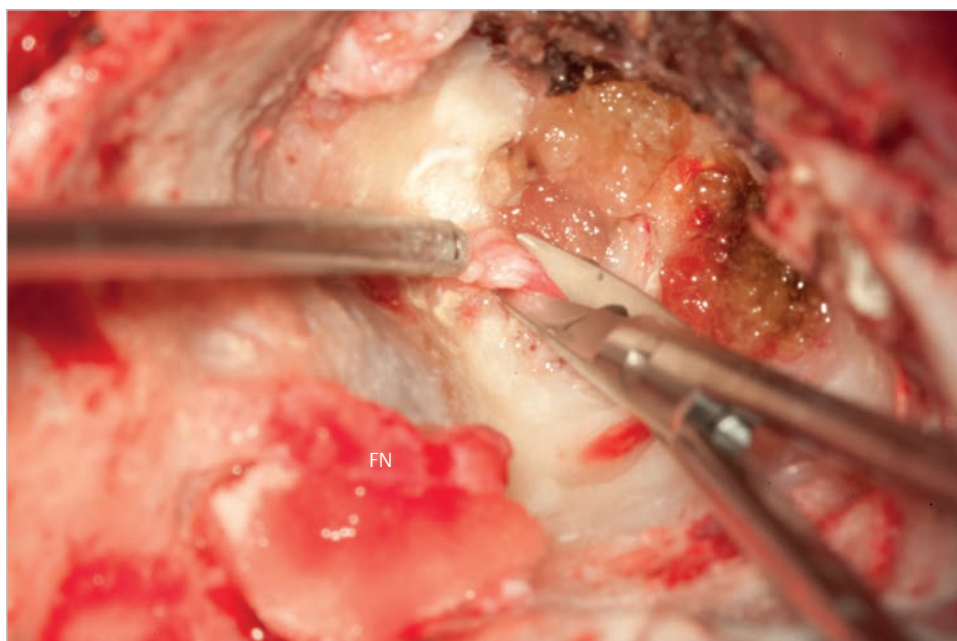


Fig. 14.344 The proximal stump of the facial nerve is refreshed with sharp scissors. FN, facial nerve.

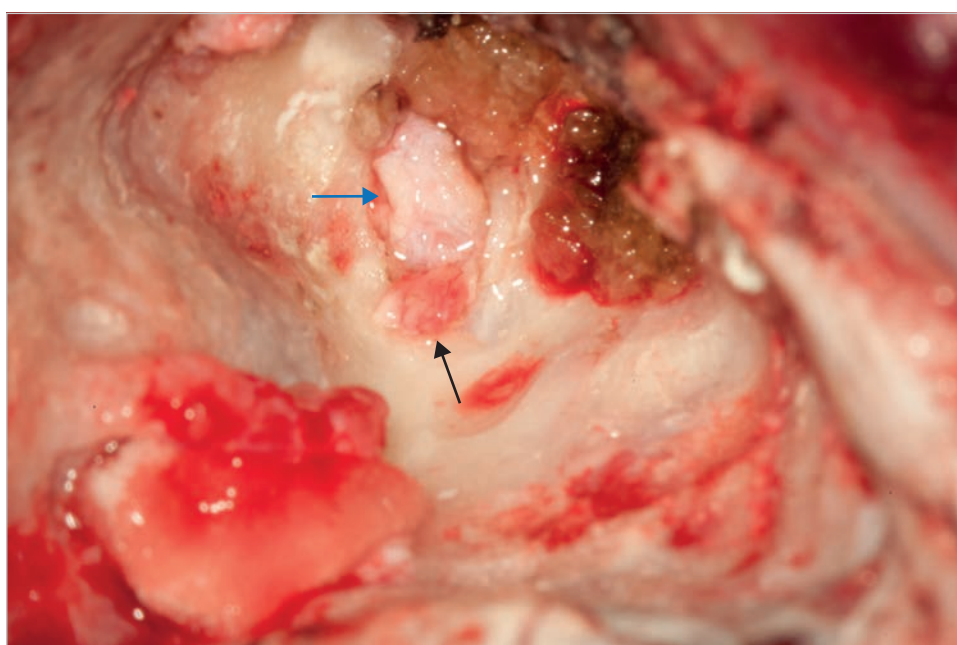


Fig. 14.345 To fix the proximal end of the facial nerve (*black arrow*), a piece of connective tissue (*blue arrow*) is applied over the nerve.

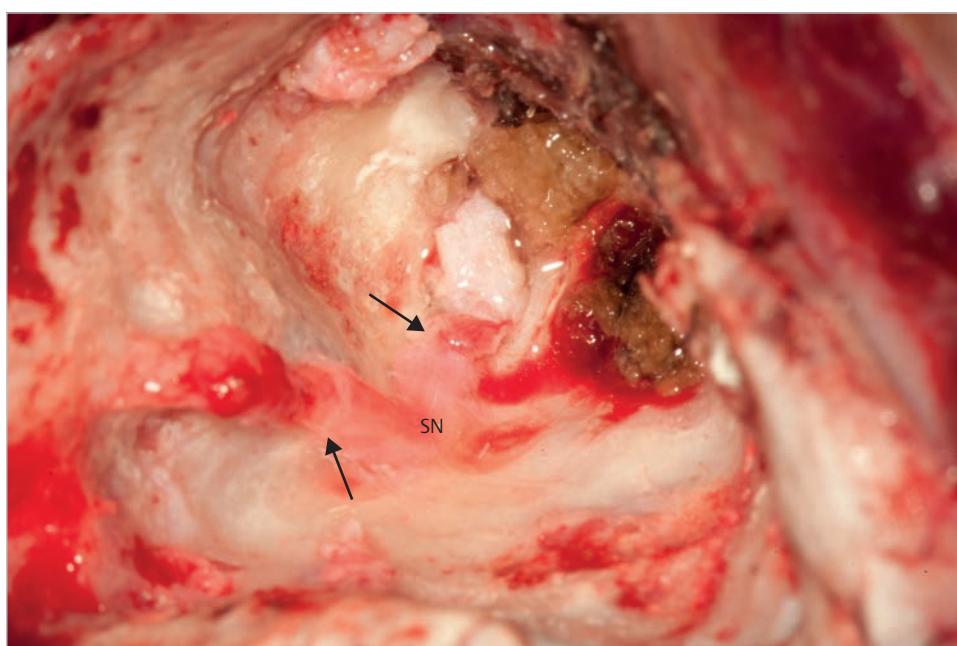


Fig. 14.346 A sural nerve is used as a grafting material. After intimately approximate the graft to both ends of the facial nerve (*arrows*), the graft is fixed with fibrin glue to the bony wall. SN, sural nerve graft.

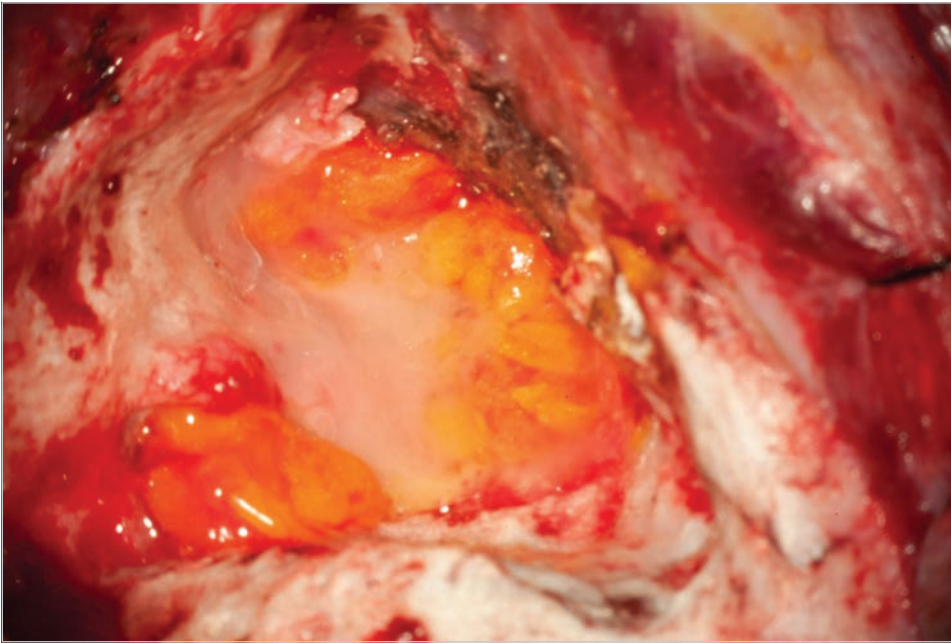


Fig. 14.347 The cavity is packed with abdominal fat.

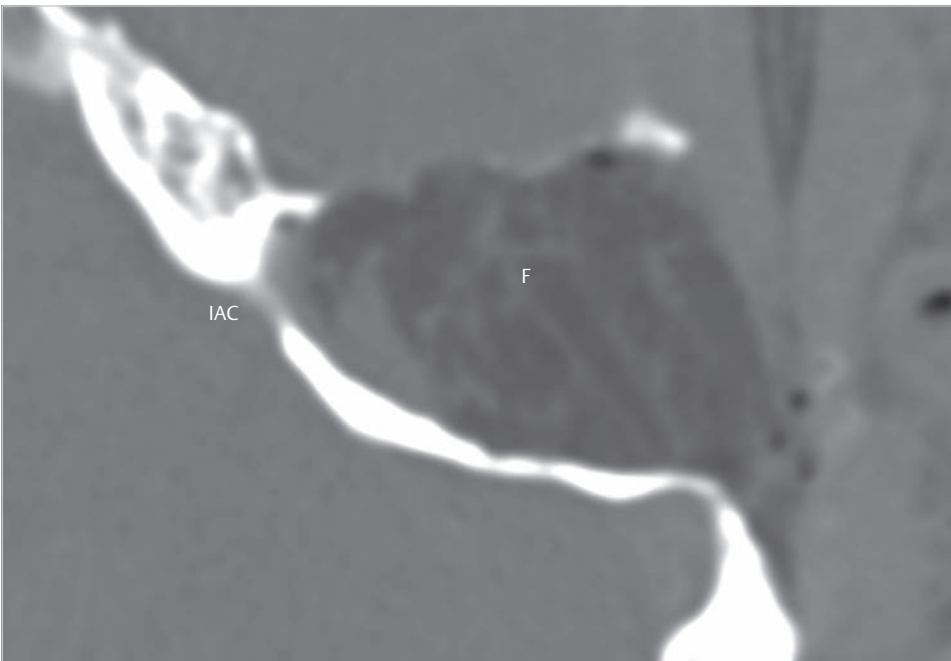


Fig. 14.348 The postoperative CT demonstrates complete removal of the labyrinth. Posterior fossa dura is not uncovered in this case due to anterosuperior localization of the pathology. F, abdominal fat; IAC, internal auditory canal.

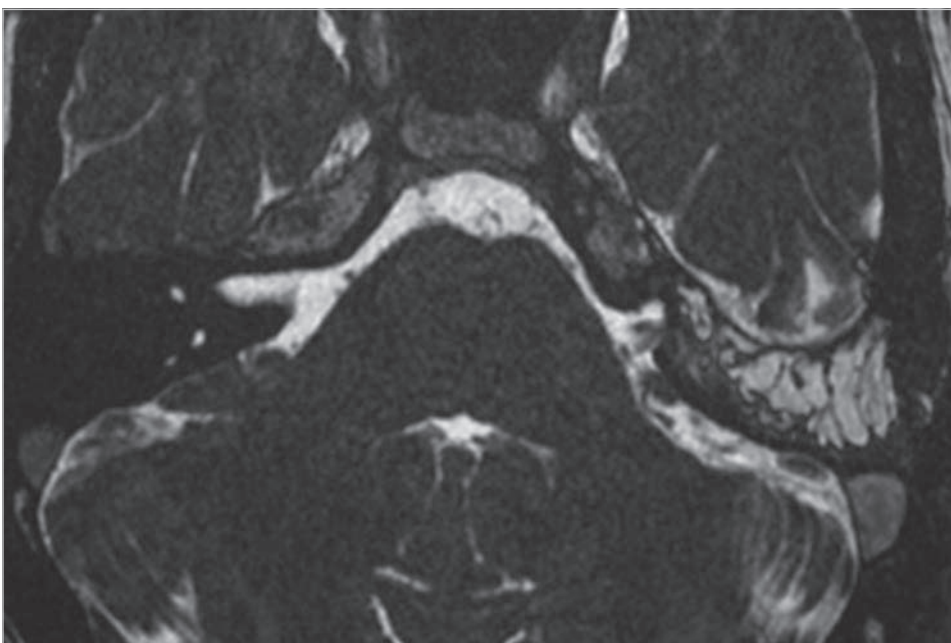


Fig. 14.349 The postoperative MRI shows extensive removal of bone from the temporal bone.

Case 14.14 (Right Ear)

See ▶Fig. 14.350, ▶Fig. 14.351, ▶Fig. 14.352, ▶Fig. 14.353, ▶Fig. 14.354, ▶Fig. 14.355, ▶Fig. 14.356, ▶Fig. 14.357, ▶Fig. 14.358, ▶Fig. 14.359, ▶Fig. 14.360, ▶Fig. 14.361.

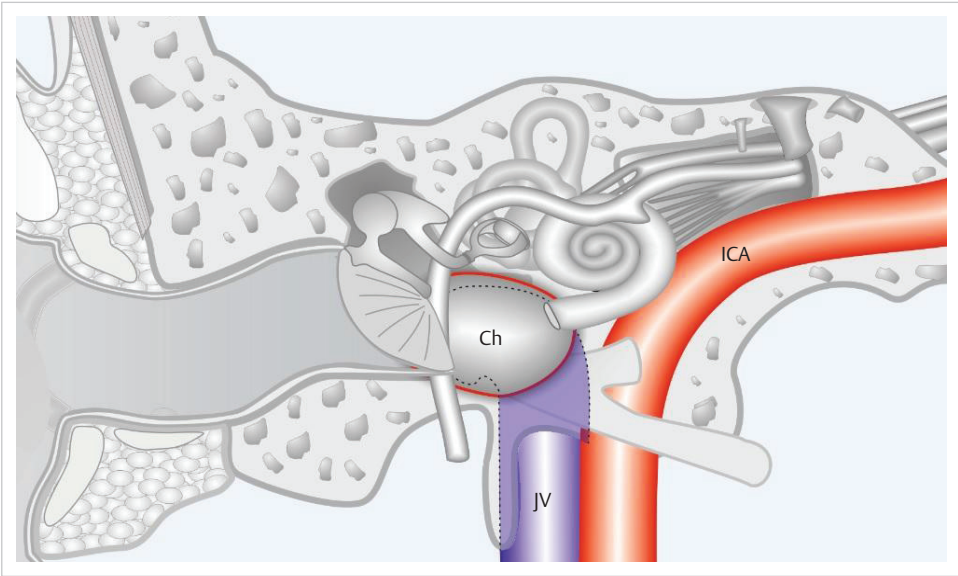


Fig. 14.350 A case of small infralabyrinthine petrous bone cholesteatoma eroding hypotympanic cells to reach the area medial to the facial nerve. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

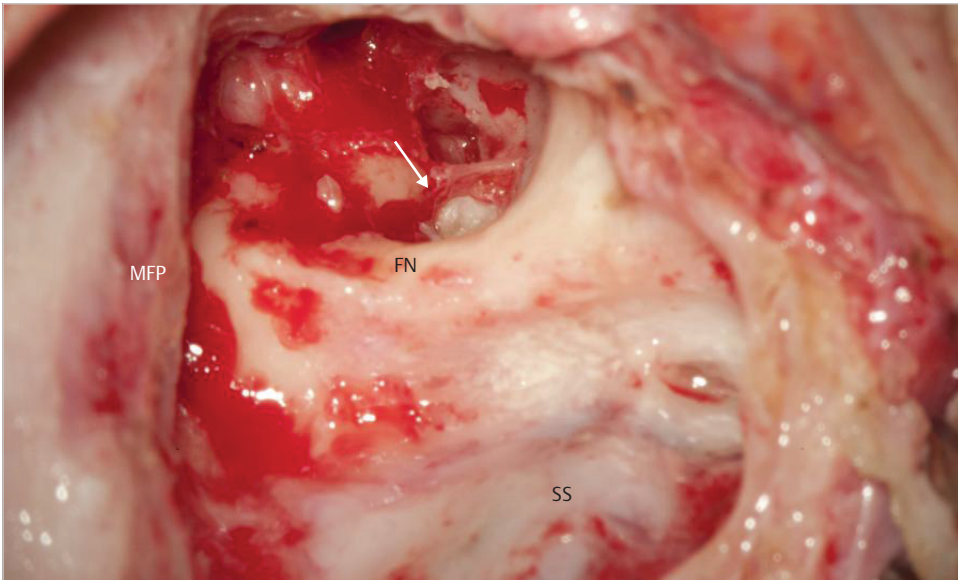


Fig. 14.351 The skin covering the cavity has already been removed, and the sigmoid sinus and the middle fossa plate are skeletonized. To eradicate cholesteatoma safely, sufficiently wide access is established by removing the posterior canal wall to such an extent that the facial nerve is skeletonized, and drilling both the anterior and inferior walls of the bony meatus. The cholesteatoma infiltrating hypotympanic cells is started to be seen (arrow). FN, facial nerve; MFP, middle fossa plate; SS, sigmoid sinus.

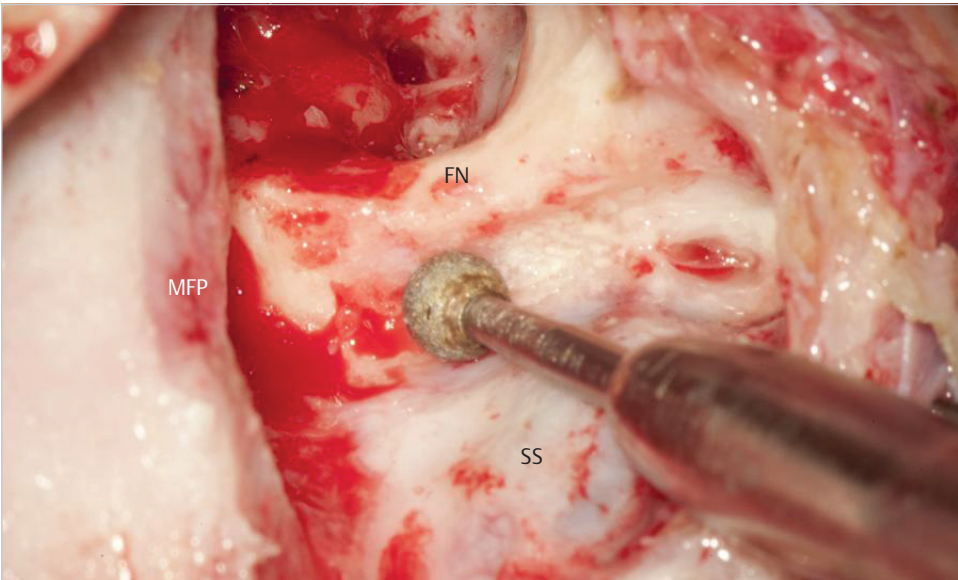


Fig. 14.352 Since the cholesteatoma extends the area under the facial nerve, retrofacial tympanotomy is indicated. To avoid damaging the facial nerve, the nerve should be positively identified and skeletonized before removing the bone under the nerve. A large diamond burr with ample irrigation is used to avoid damaging the nerve physically and thermally. FN, facial nerve; MFP, middle fossa plate; SS, sigmoid sinus.

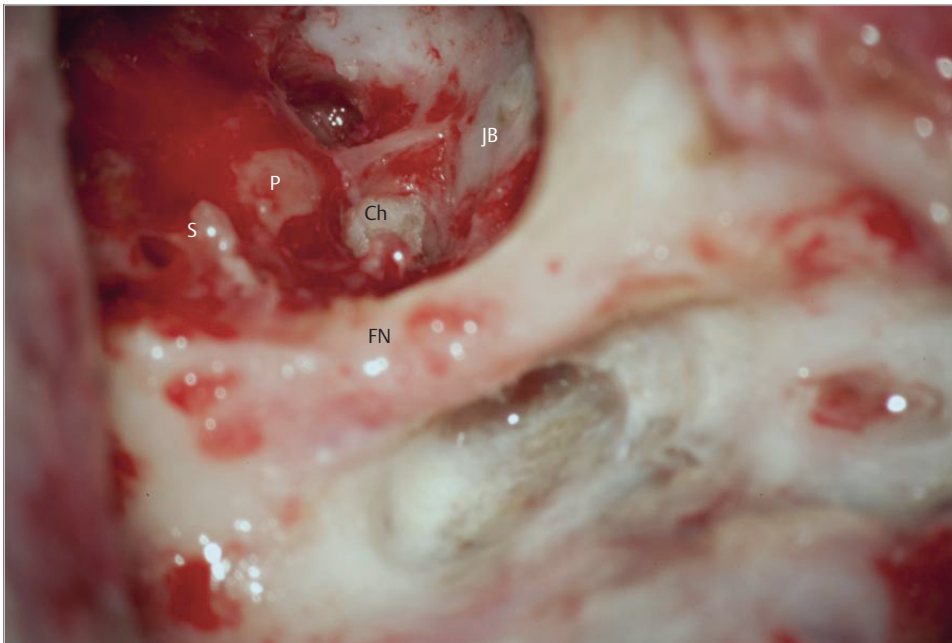


Fig. 14.353 Cholesteatoma infiltrating the hypotympanic cells is shown. A large anteriorly located jugular bulb forms floor of the tympanic cavity. Ch, cholesteatoma; FN, facial nerve; JB, jugular bulb; P, promontory; S, stapes.

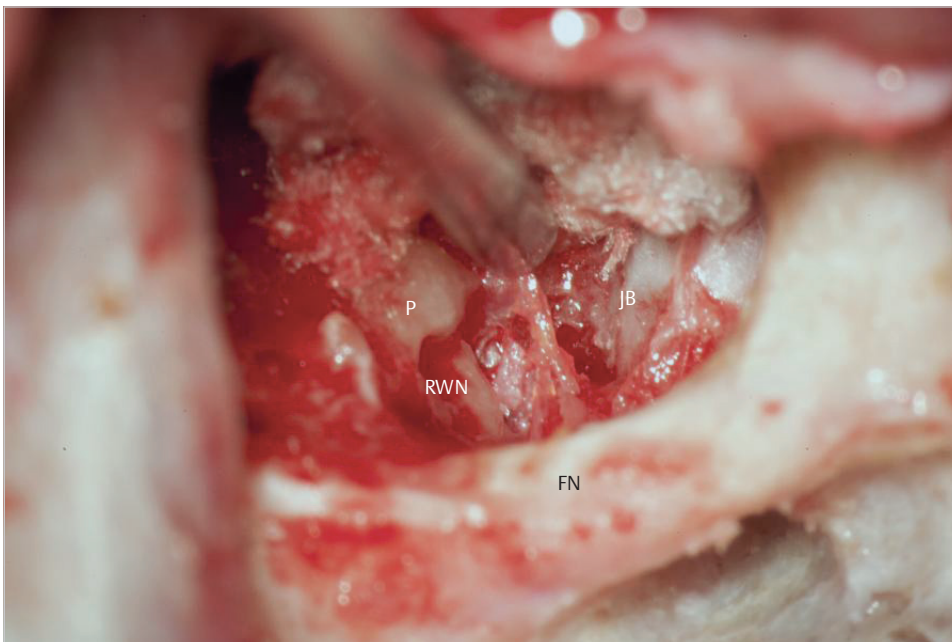


Fig. 14.354 Dissection of cholesteatoma from hypotympanic cells is in progress. FN, facial nerve; JB, jugular bulb; P, promontory; RWN, round window niche.

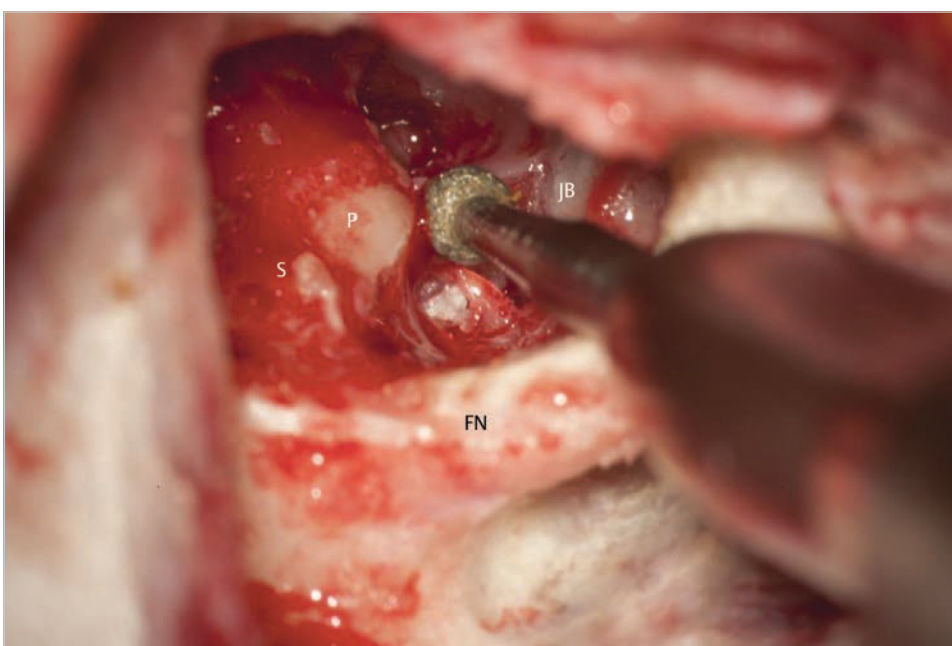


Fig. 14.355 The hypotympanic cells are opened with a small diamond burr taking care not to damage the jugular bulb. FN, facial nerve; JB, jugular bulb; P, promontory; S, stapes.

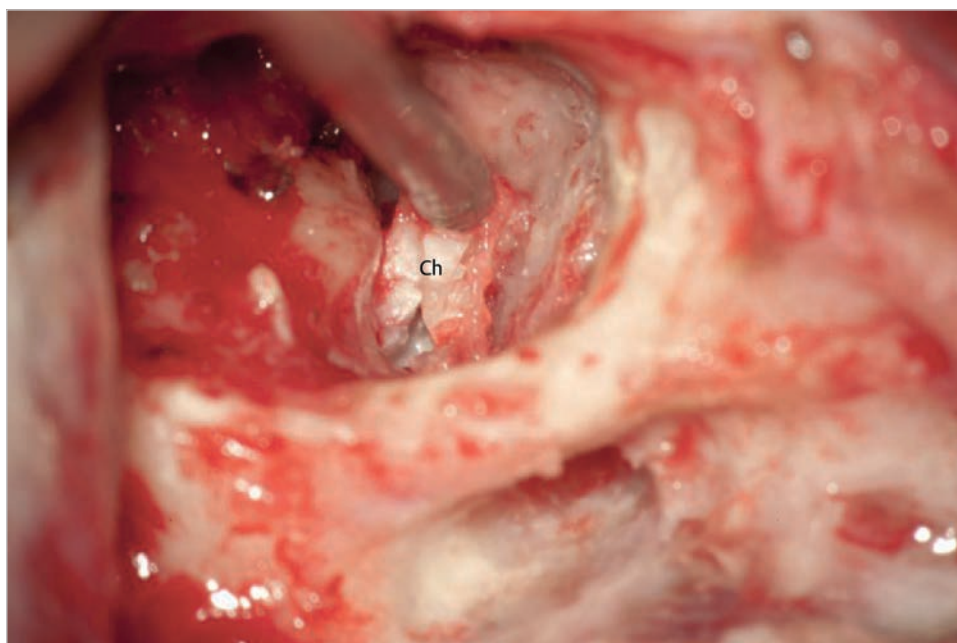


Fig. 14.356 The cholesteatoma infiltrating hypotympanic cells is seen. Ch, cholesteatoma.

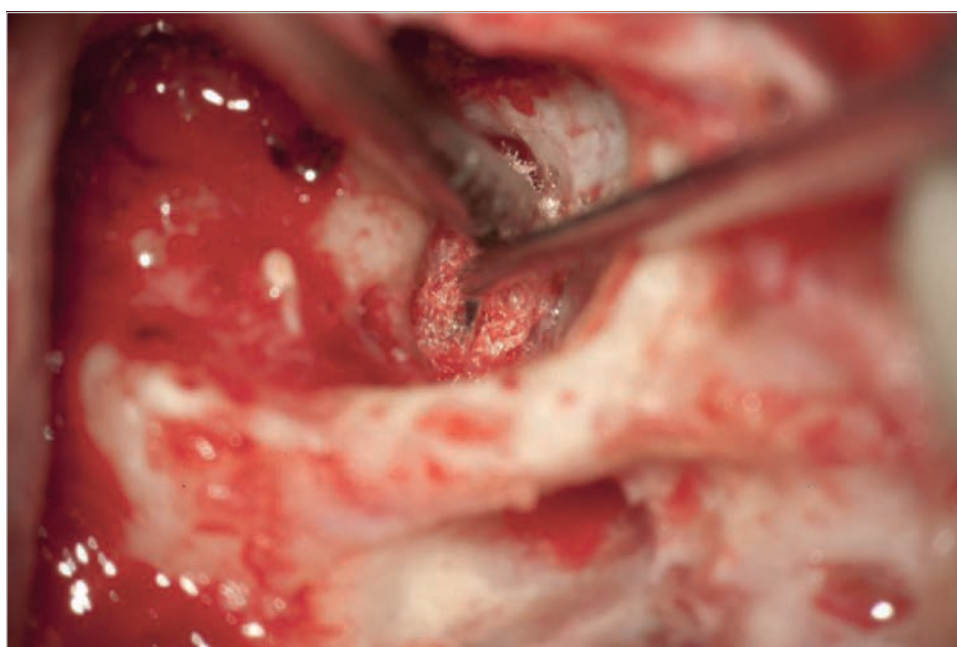


Fig. 14.357 The cholesteatoma matrix is dissected from the hypotympanum with the help of cottonoid.

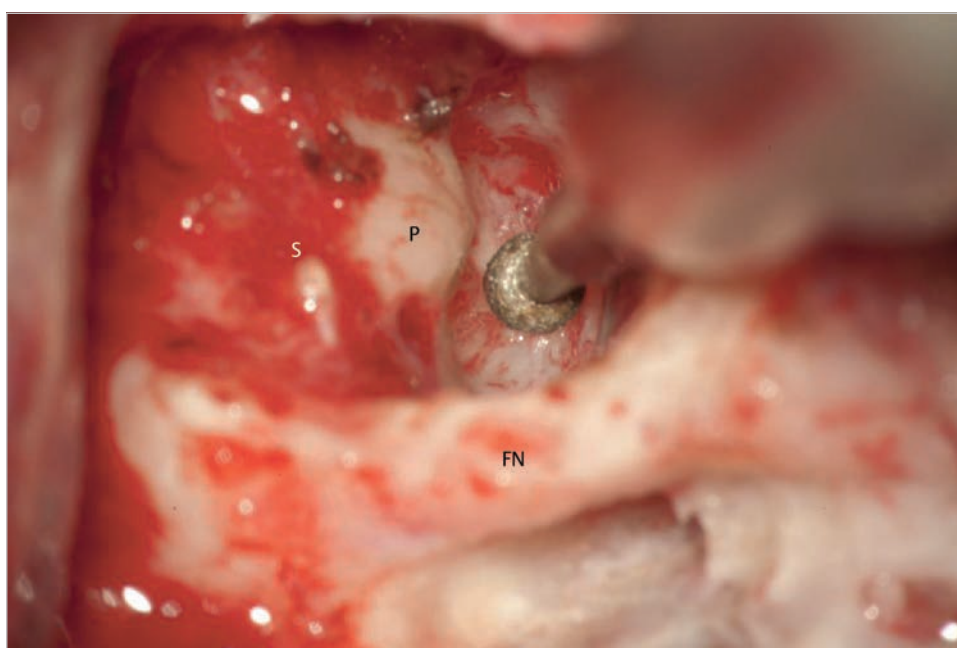


Fig. 14.358 The cells suspicious of residual matrix should be drilled thoroughly. FN, facial nerve; P, promontory; S, stapes.

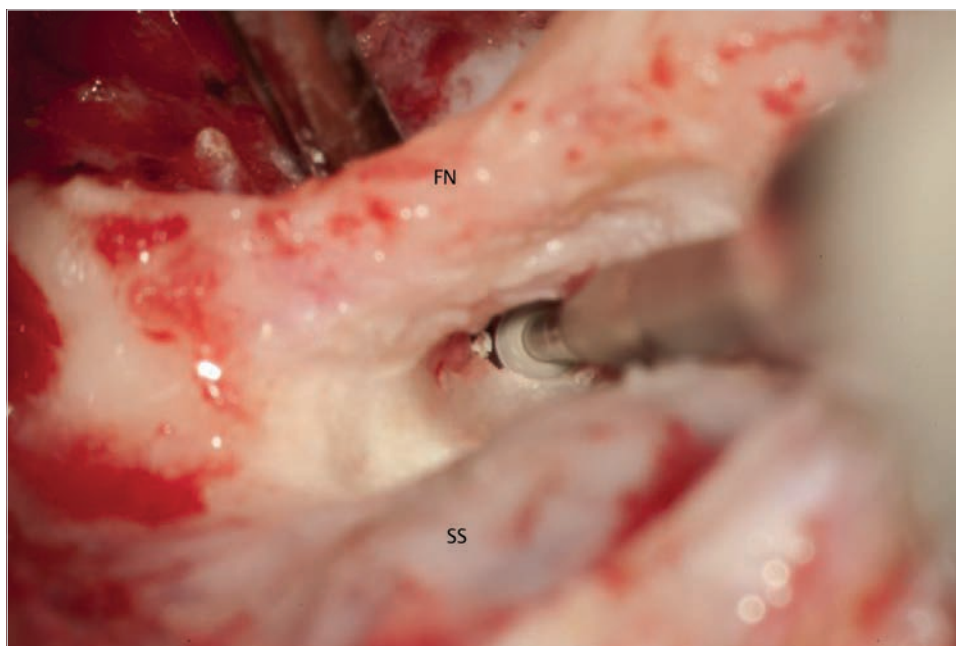


Fig. 14.359 To control the posterior face of the cholesteatoma, the retrofacial tympanotomy is carried out with a small diamond burr. Great care should be taken not to damage the facial nerve and the sigmoid sinus with the shaft of the burr. The facial nerve, the jugular bulb, and the ampulla of the posterior semicircular canal limit the size of the opening laterally, inferiorly, and superiorly, respectively. FN, facial nerve; SS, sigmoid sinus.

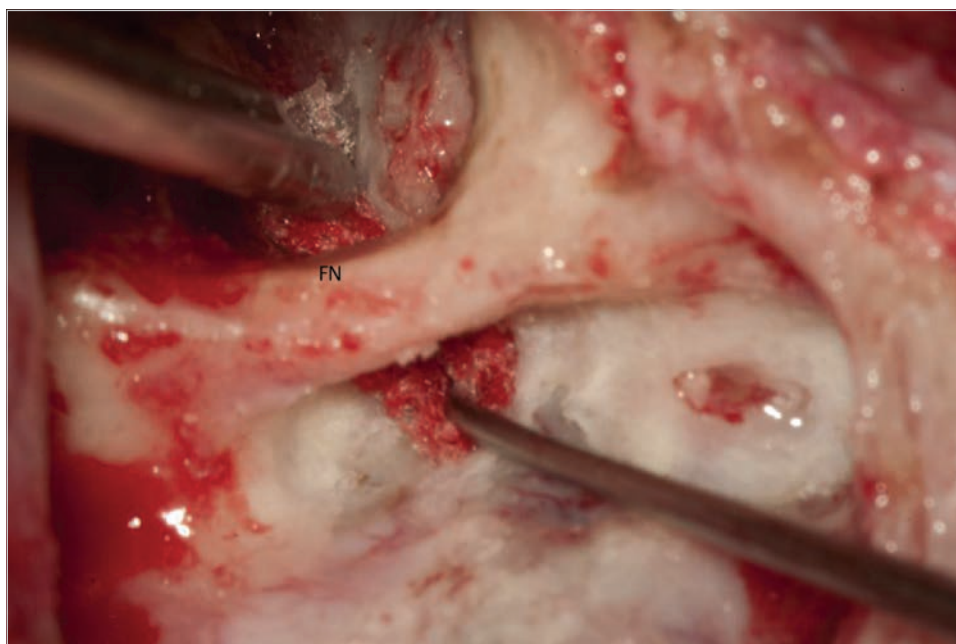


Fig. 14.360 Bony walls are scrubbed with cottonoid to verify complete removal of the matrix. FN, facial nerve.

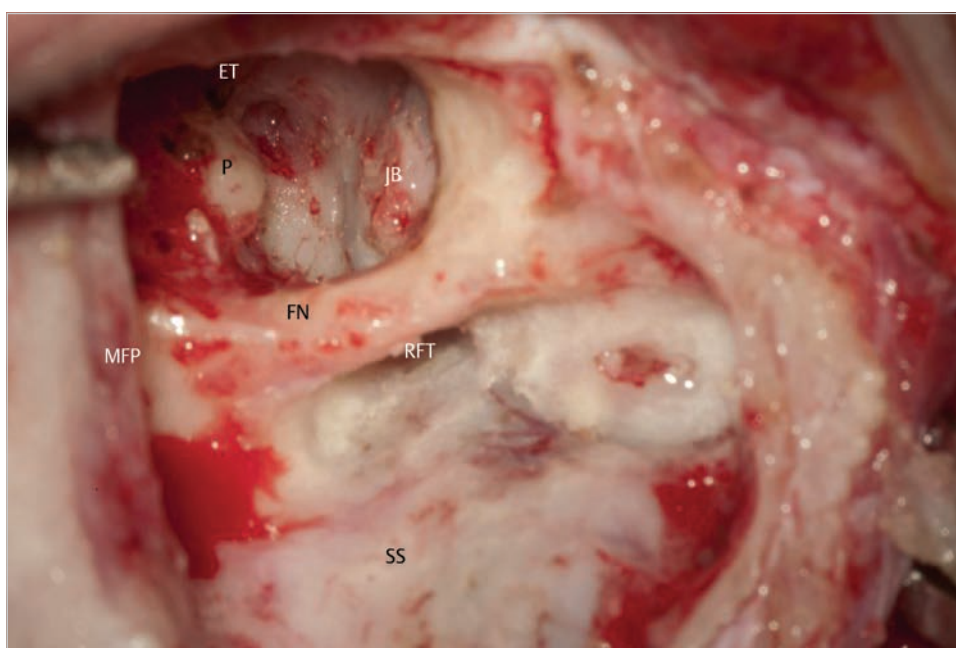


Fig. 14.361 Cholesteatoma is eradicated from the middle ear. After obliterating the eustachian tube with periosteum, the cavity is packed with abdominal fat. ET, eustachian tube; FN, facial nerve; JB, jugular bulb; MFP, middle fossa plate; P, promontory; RFT, retrofacial tympanotomy; SS, sigmoid sinus.

Case 14.15 (Left Ear)

See ▶Fig. 14.362, ▶Fig. 14.363, ▶Fig. 14.364, ▶Fig. 14.365, ▶Fig. 14.366, ▶Fig. 14.367, ▶Fig. 14.368, ▶Fig. 14.369, ▶Fig. 14.370, ▶Fig. 14.371, ▶Fig. 14.372, ▶Fig. 14.373▶Fig. 14.374, ▶Fig. 14.375, ▶Fig. 14.376, ▶Fig. 14.377.

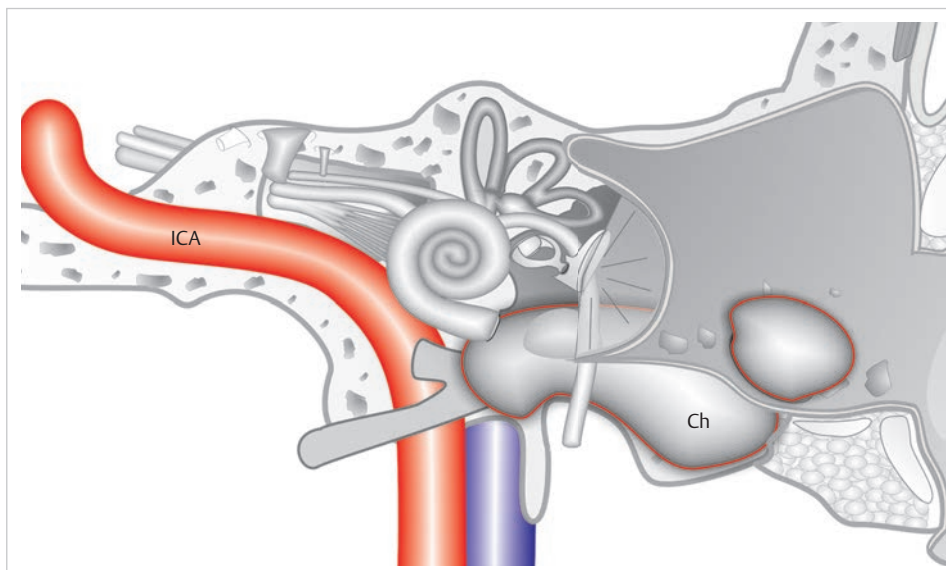


Fig. 14.362 A case of infralabyrinthine petrous bone cholesteatoma arose in a form of recurrence in the old radical cavity removed with subtotal petrosectomy. The cholesteatoma starts from the mastoid tip, passing under the facial nerve to reach hypotympanic cells. The otic capsule is not insulted. Ch, cholesteatoma; ICA, internal carotid artery.

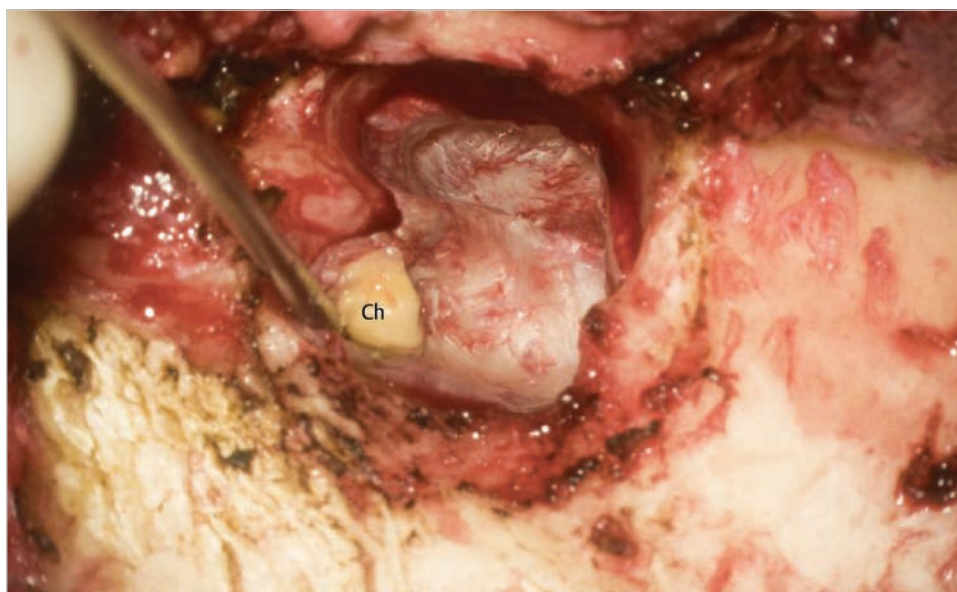


Fig. 14.363 The patient underwent canal wall down tympanoplasty followed by sustained otorrhea. Preoperative CT shows soft tissue density located medially to the facial nerve, going far anteriorly toward the jugular bulb. Since the patient has no serviceable hearing, cul de sac closure of the external auditory canal with obliteration of the cavity with abdominal fat is indicated. An orifice of cholesteatoma filled with debris is seen in the mastoid tip. Ch, cholesteatoma.

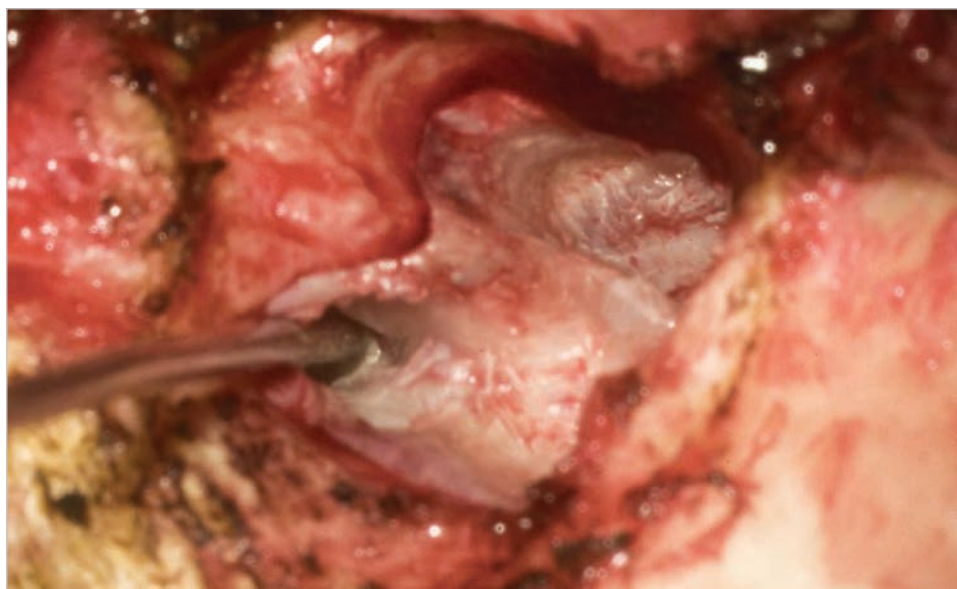


Fig. 14.364 A suction is introduced into the cholesteatoma to remove debris.

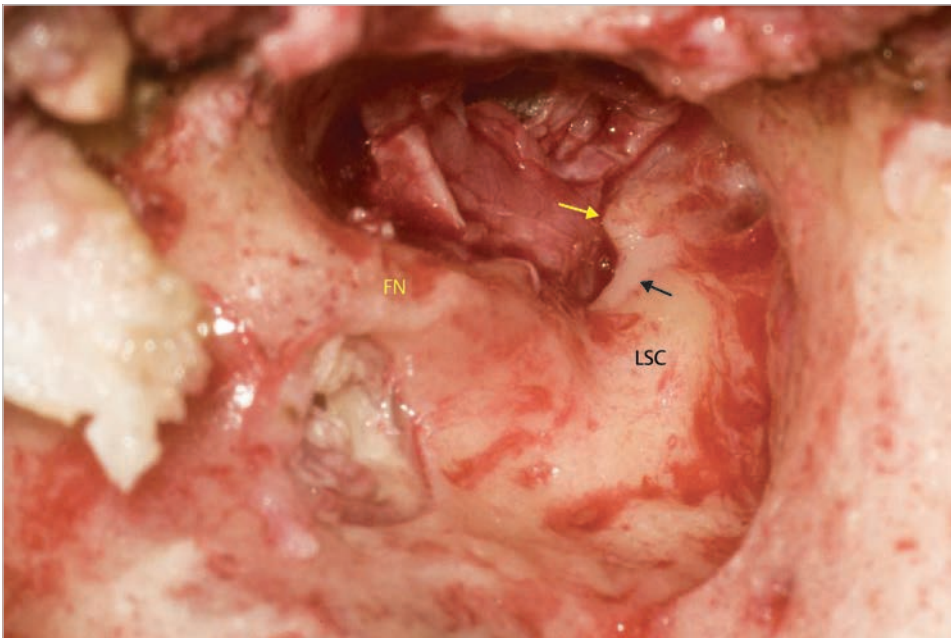


Fig. 14.365 The skin covering the cavity is detached, and sharp edges in the cavity are removed. The tympanic membrane is reflected anteriorly. The tympanic segment of the facial nerve (*black arrow*) coursing just superiorly to the cochleariform process (*yellow arrow*) and passes inferomedially to the lateral semicircular canal is seen. FN, facial nerve; LSC, lateral semicircular canal.

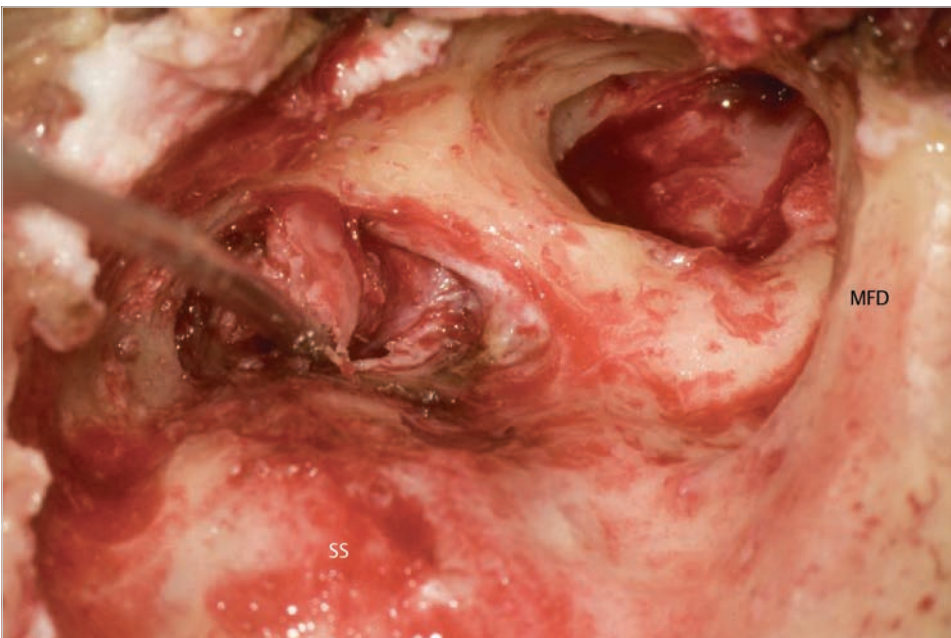


Fig. 14.366 Before starting dissection of cholesteatoma, bone work to skeletonize the sigmoid sinus and the middle fossa plate is completed to maximize the approach for safe removal of the cholesteatoma. MFD, middle fossa dura; SS, sigmoid sinus.

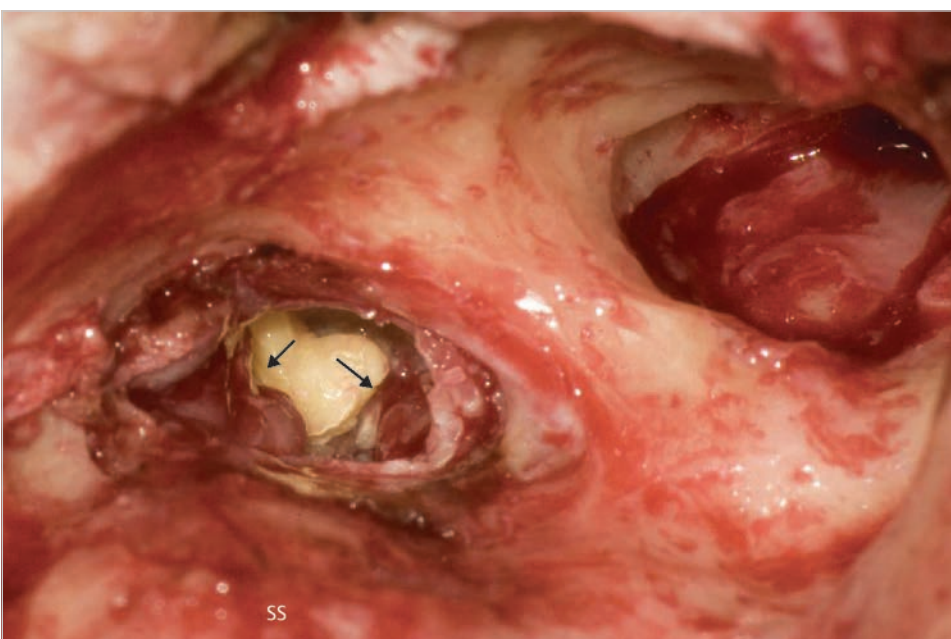


Fig. 14.367 The cholesteatoma reaches far anteriorly and inferiorly beneath the facial ridge. Granulation tissue is seen inside of it (*arrows*). SS, sigmoid sinus.



Fig. 14.368 Removal of debris revealed that the cholesteatoma invaginates into other cells located in vicinity. The bony annulus is removed to drill hypotympanic cells infiltrated by the cholesteatoma (*arrow*). FN, facial nerve.



Fig. 14.369 Closer view. The cholesteatoma invaginates into a deep cell going anteriorly. FN, facial nerve.

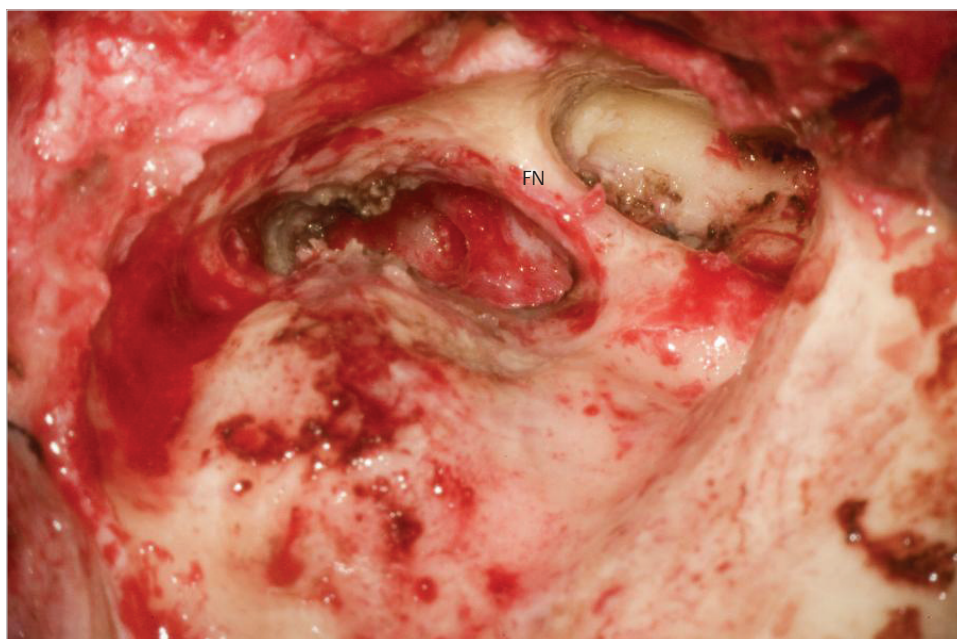


Fig. 14.370 Small opening of the cell is enlarged, and the cholesteatoma is removed from it. Note wide opening of the cavity to enhance surgical view of cholesteatoma. FN, facial nerve.

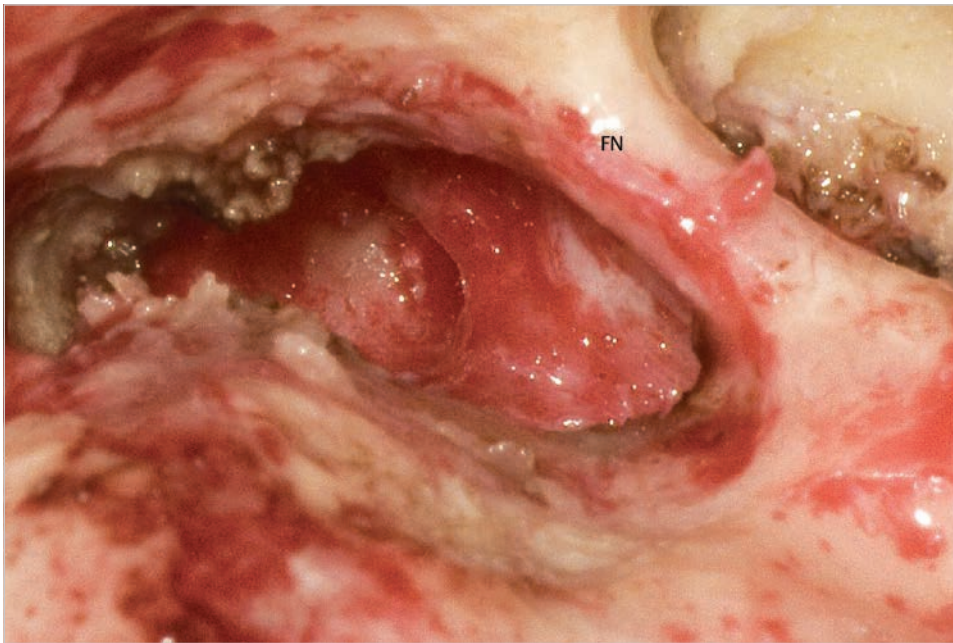


Fig. 14.371 Closer view. Cholesteatoma invaginating into the cell is completely removed. FN, facial nerve.

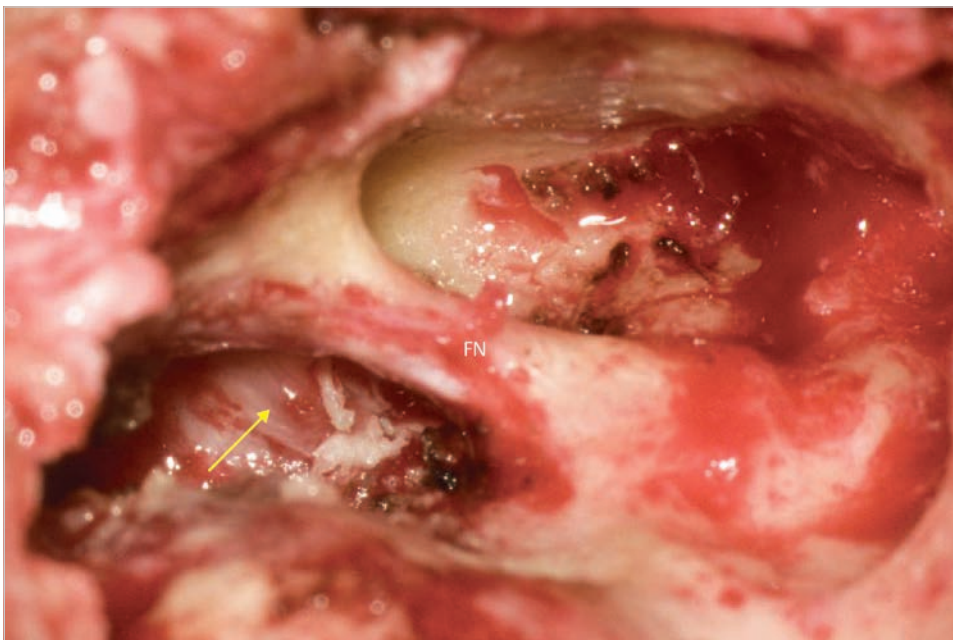


Fig. 14.372 The matrix covering the jugular bulb (*arrow*) infiltrating the hypotympanic cells is shown. FN, facial nerve.

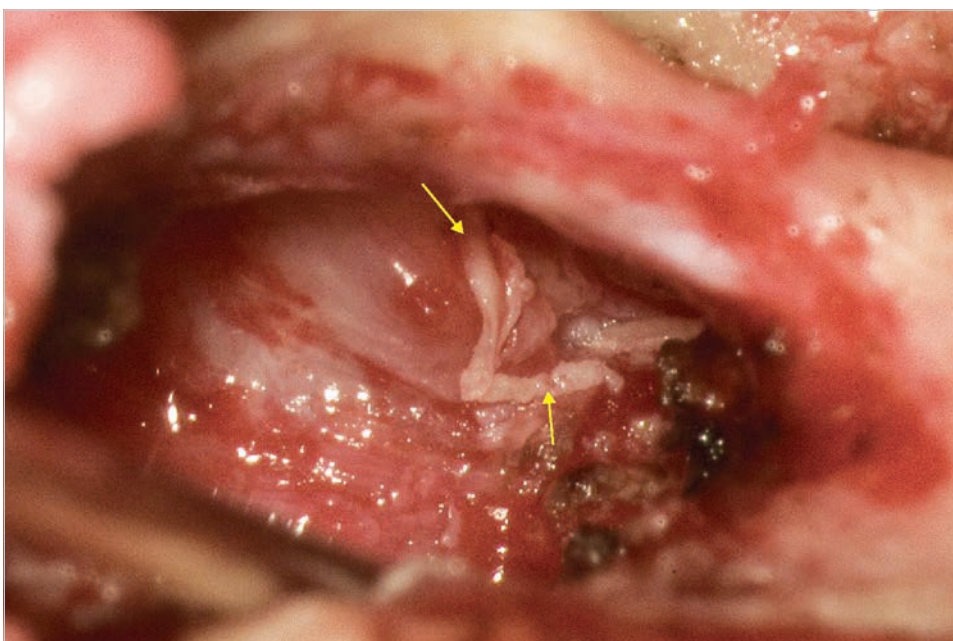


Fig. 14.373 Closer view. The skin surpasses the jugular bulb, reaching the area of the hypotympanum (*arrows*).

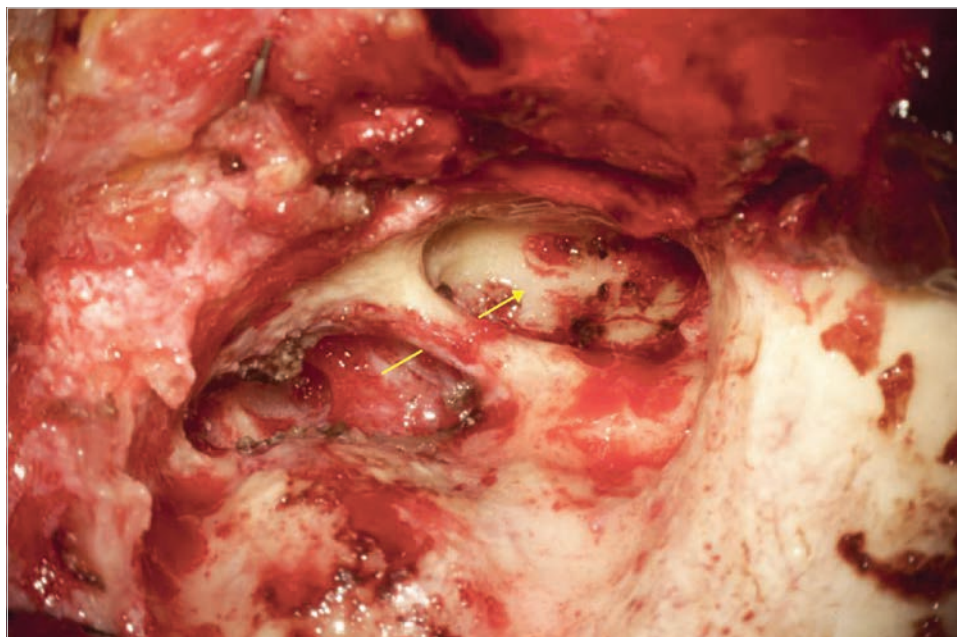


Fig. 14.374 Subfacial tympanotomy to remove the cholesteatoma in hypotympanic cells are carried out, and the cholesteatoma is completely removed. Note the wide opening of the subfacial area connected to the hypotympanum (*arrow*).

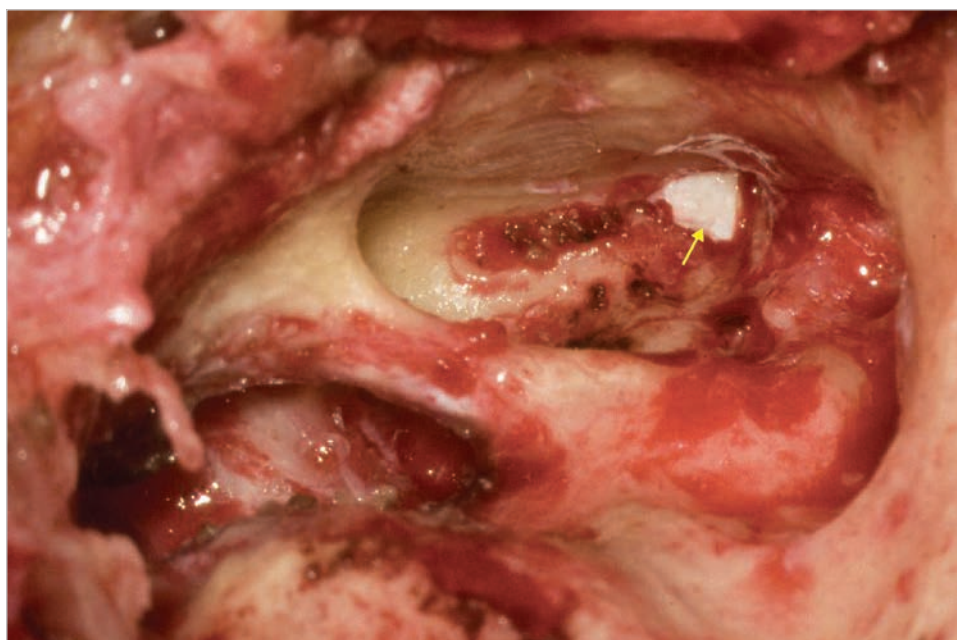


Fig. 14.375 The eustachian tube is obliterated with pieces of periosteum (*arrow*).

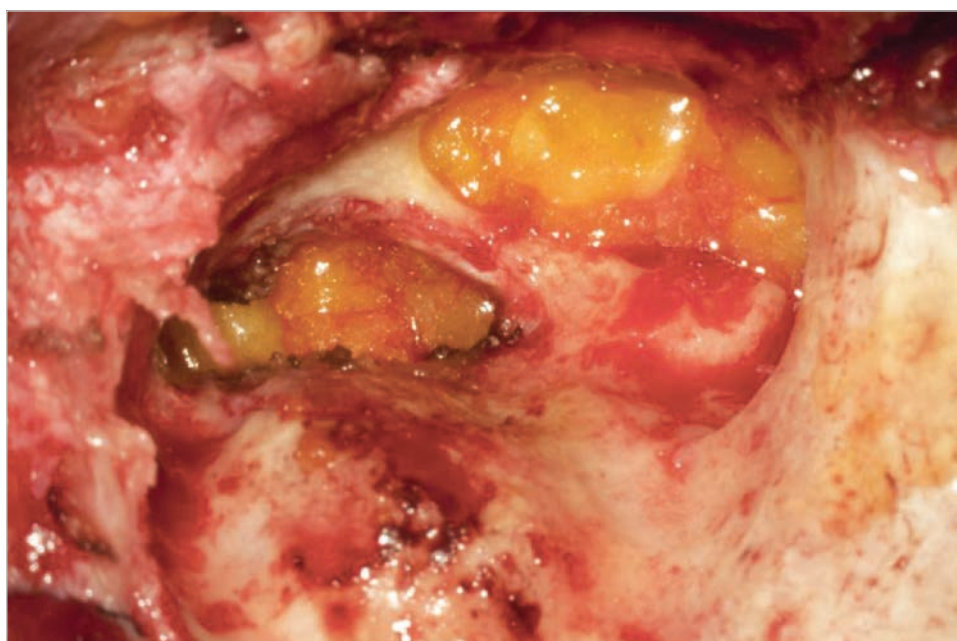


Fig. 14.376 The cavity is obliterated with abdominal fat so as not to make draining ear with poor hearing.

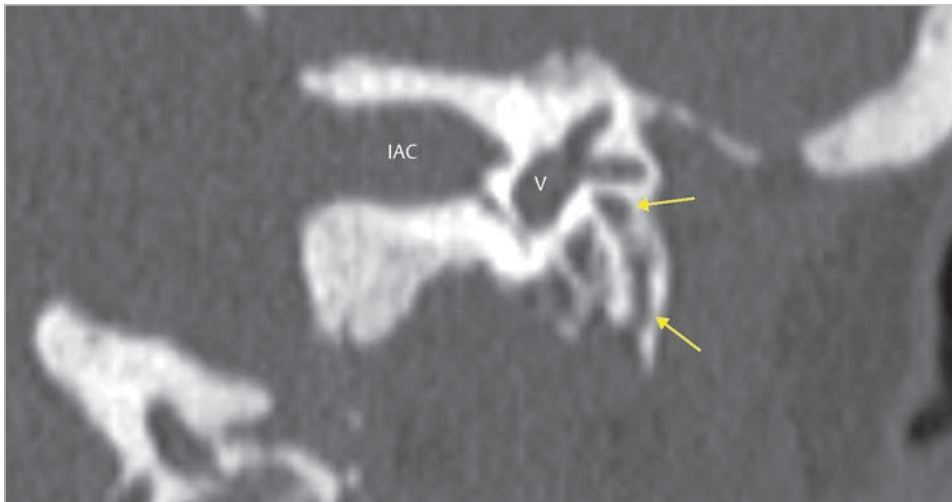


Fig. 14.377 The postoperative CT in coronal section shows wide access to the hypotympanic area. The skeletonized facial nerve passing under the lateral semicircular canal is indicated by arrows. IAC, internal auditory canal; V, vestibule.

Case 14.16 (Right Ear)

See ▶ Fig. 14.378, ▶ Fig. 14.379, ▶ Fig. 14.380, ▶ Fig. 14.381, ▶ Fig. 14.382, ▶ Fig. 14.383, ▶ Fig. 14.384, ▶ Fig. 14.385, ▶ Fig. 14.386, ▶ Fig. 14.387, ▶ Fig. 14.388, ▶ Fig. 14.389, ▶ Fig. 14.390, ▶ Fig. 14.391, ▶ Fig. 14.392, ▶ Fig. 14.393, ▶ Fig. 14.394, ▶ Fig. 14.395, ▶ Fig. 14.396, ▶ Fig. 14.397, ▶ Fig. 14.398, ▶ Fig. 14.399, ▶ Fig. 14.400, ▶ Fig. 14.401, ▶ Fig. 14.402, ▶ Fig. 14.403, ▶ Fig. 14.404, ▶ Fig. 14.405, ▶ Fig. 14.406, ▶ Fig. 14.407, ▶ Fig. 14.408, ▶ Fig. 14.409, ▶ Fig. 14.410, ▶ Fig. 14.411.

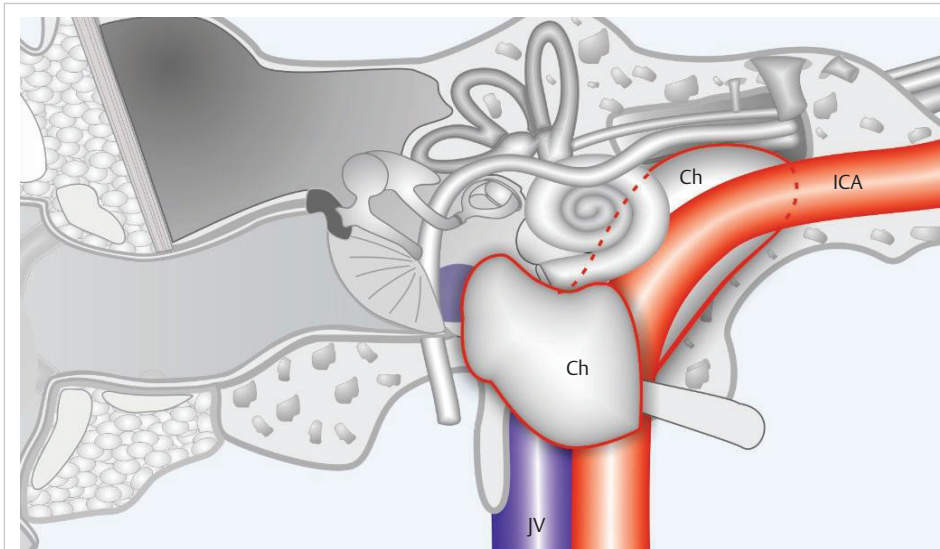


Fig. 14.378 A case of infralabyrinthine-apical petrous bone cholesteatoma eroding the internal auditory canal and the jugular foramen removed with transotic approach. The 40-year-old patient underwent tympanoplasty for cholesteatoma 3 years ago elsewhere. Otorrhea and earache recurred, and radiologic examination revealed petrous bone cholesteatoma reaching the petrous apex. Otoscopic examination showed retracted tympanic membrane with a small perforation in posterosuperior quadrant. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

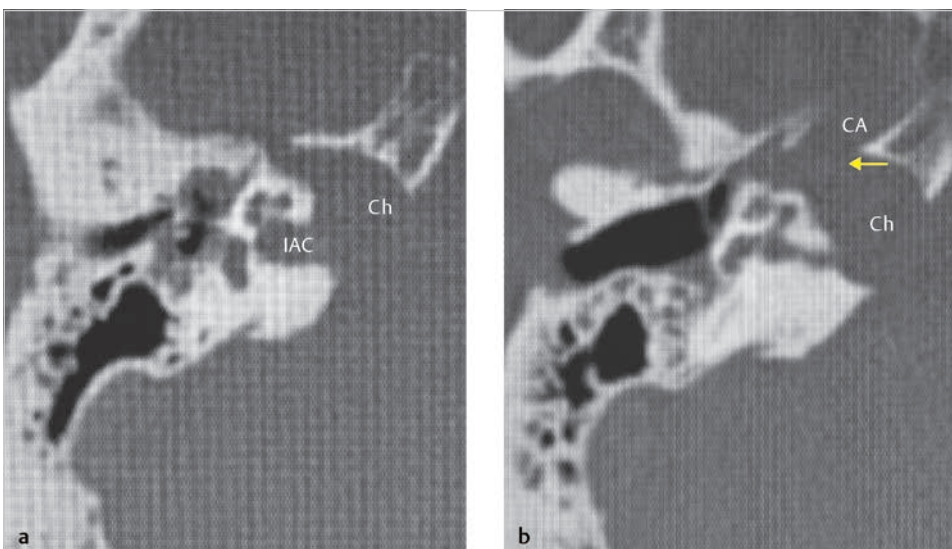


Fig. 14.379 The axial CT (a) shows presence of soft tissue density in the petrous apex eroding the internal auditory canal from inferior (a). The posteroinferior face of the carotid canal is also eroded (b) (arrow). Ch, cholesteatoma; CA, carotid artery; IAC, internal auditory canal.

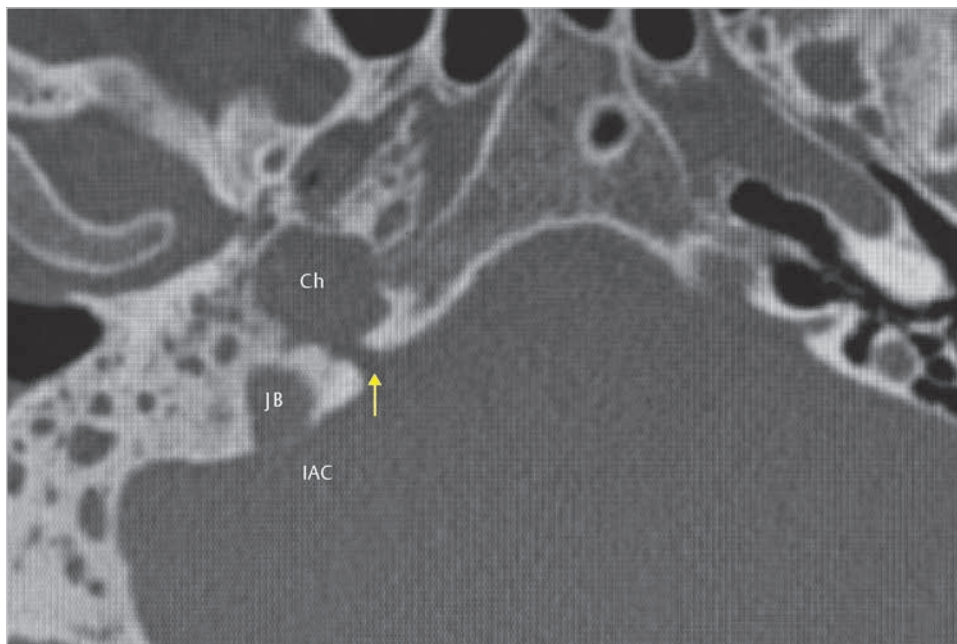


Fig. 14.380 In more caudal slice, the cholesteatoma eroding the pars nervosa of the jugular foramen (*arrow*) is shown. Ch, cholesteatoma; IAC, internal auditory canal; JB, jugular bulb.

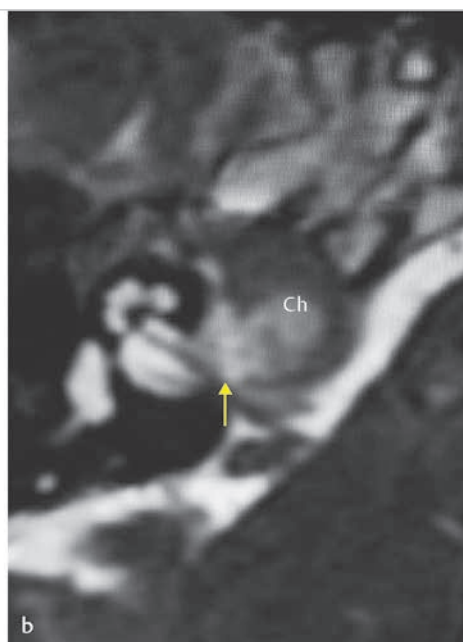
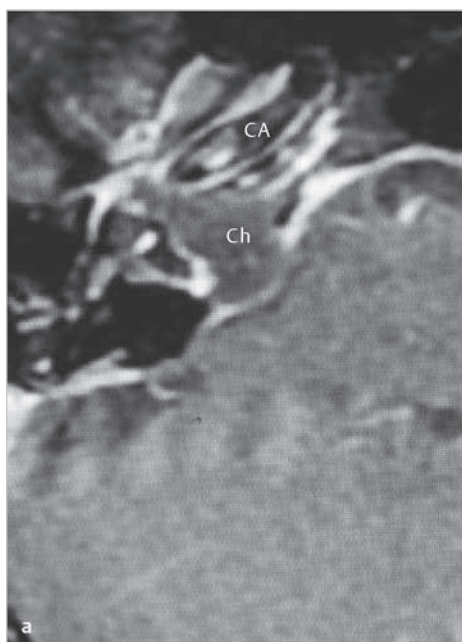


Fig. 14.381 The MRI shows a mass of moderate signal intensity in T1 with no enhancement with gadolinium, and mosaic of high and moderate signal intensity in T2. The internal auditory canal (*yellow arrow*) is infiltrated by the cholesteatoma. Signal intensity of the cochlea in T2 is decreased suggesting either fibrosis or ossification. CA, carotid artery; Ch, cholesteatoma.

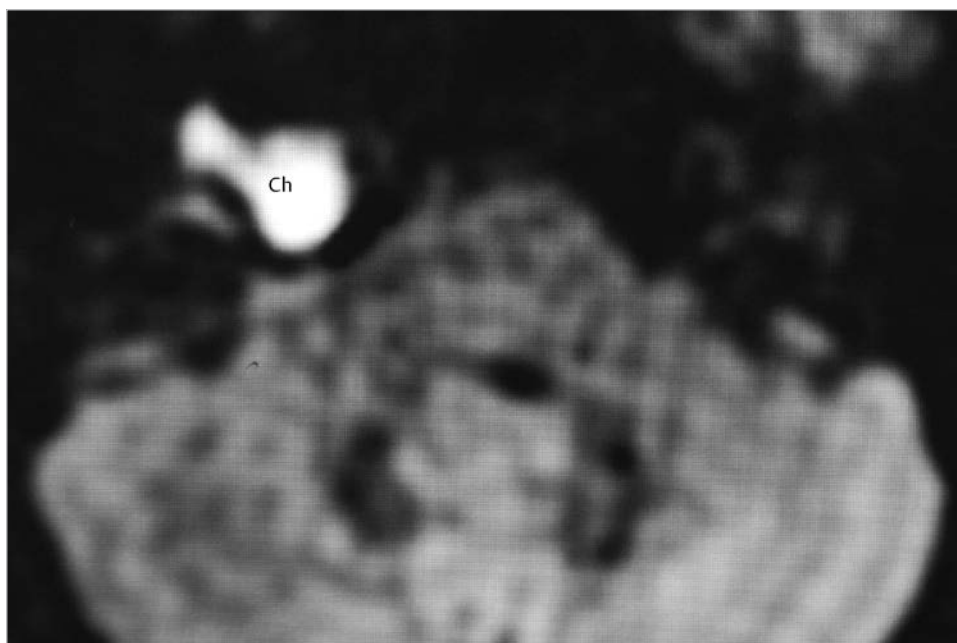


Fig. 14.382 The diffusion-weighted MR imaging sequence clearly discriminates the cholesteatoma with its high signal from surrounding structures. Ch, cholesteatoma.

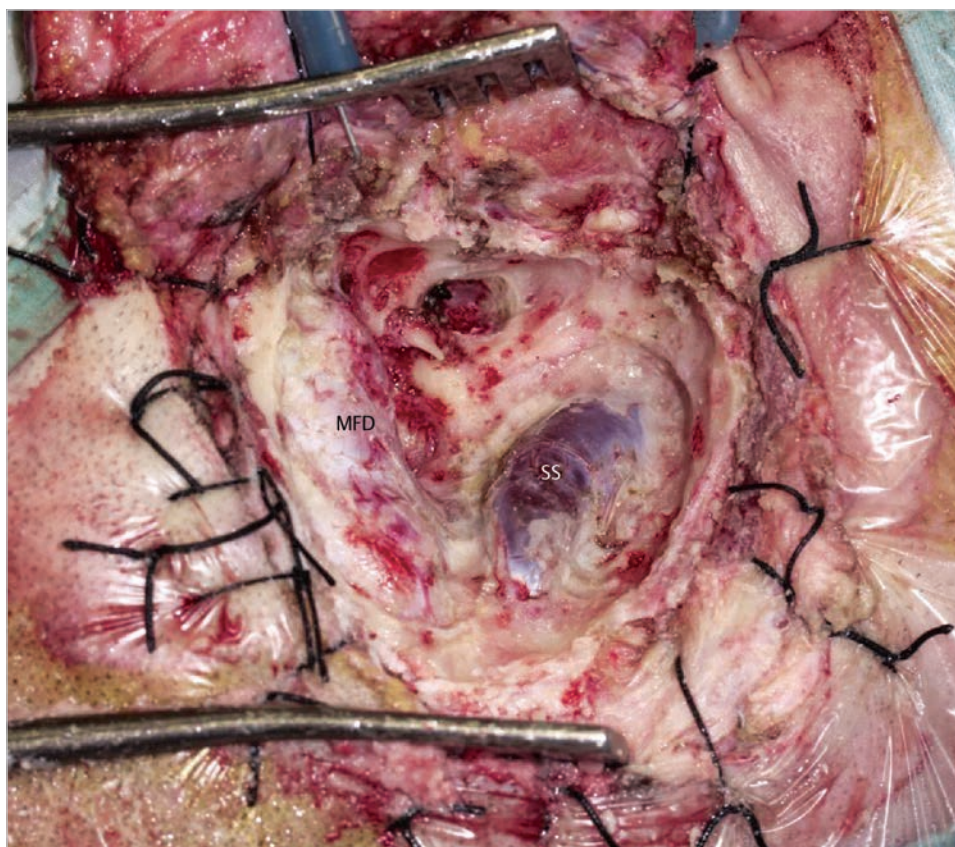


Fig. 14.383 Preparation for removal of the petrous bone cholesteatoma is shown. For maximum exposure of the surgical field without any impediments, stitches are used to hold the musculoperiosteal layer away from the surgical field. The skin retractor should be taken away before drilling is advanced medially. The posterior meatal wall is removed, and the sigmoid sinus and the middle fossa dura are already exposed to enhance handling of the petrous apex. MFD, middle fossa dura; SS, sigmoid sinus.

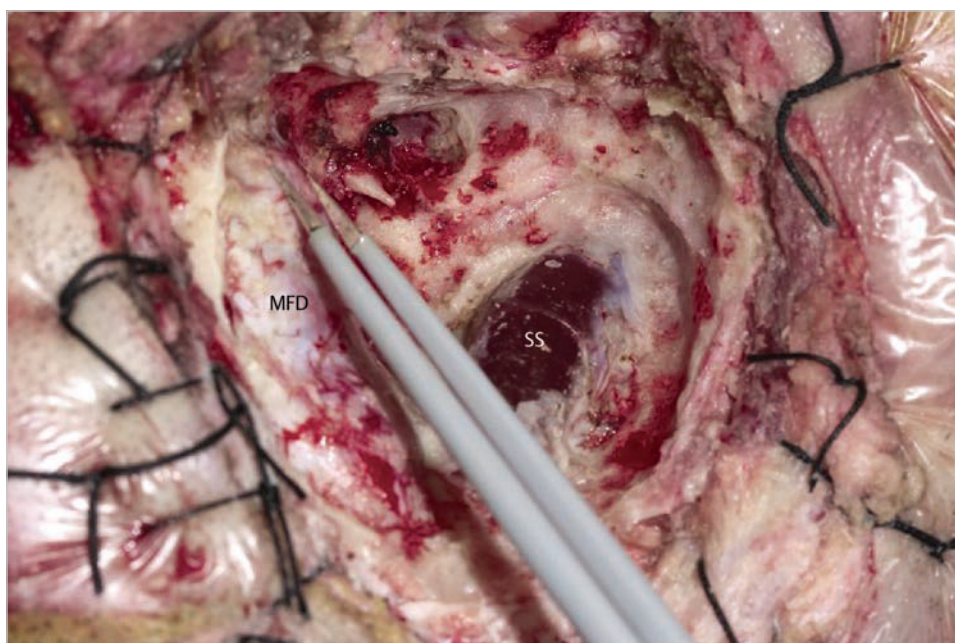


Fig. 14.384 The bulging of the middle fossa dura is shrunk with bipolar coagulation to enlarge access to the medial structures. This technique can be used on the sigmoid sinus, and is important to stop bleeding from dura, and to eliminate possible remnant of the cholesteatoma matrix. MFD, middle fossa dura; SS, sigmoid sinus.

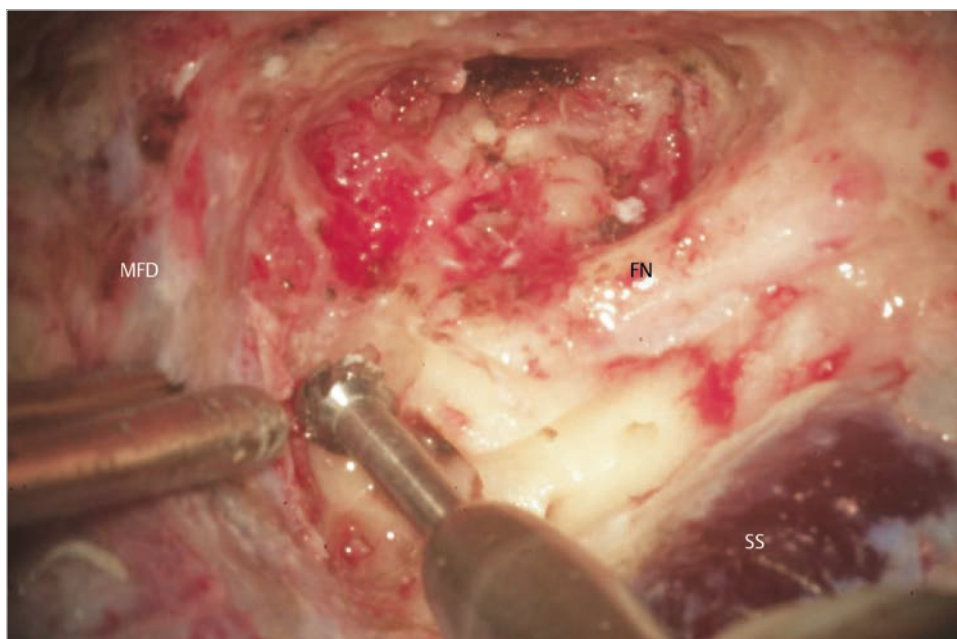


Fig. 14.385 The tympanomeatal flap and the ossicular chain have been removed. The facial nerve is skeletonized. Labyrinthectomy is carried out with a large cutting bur, taking care not to damage the facial nerve. FN, facial nerve; MFD, middle fossa dura; SS, sigmoid sinus.

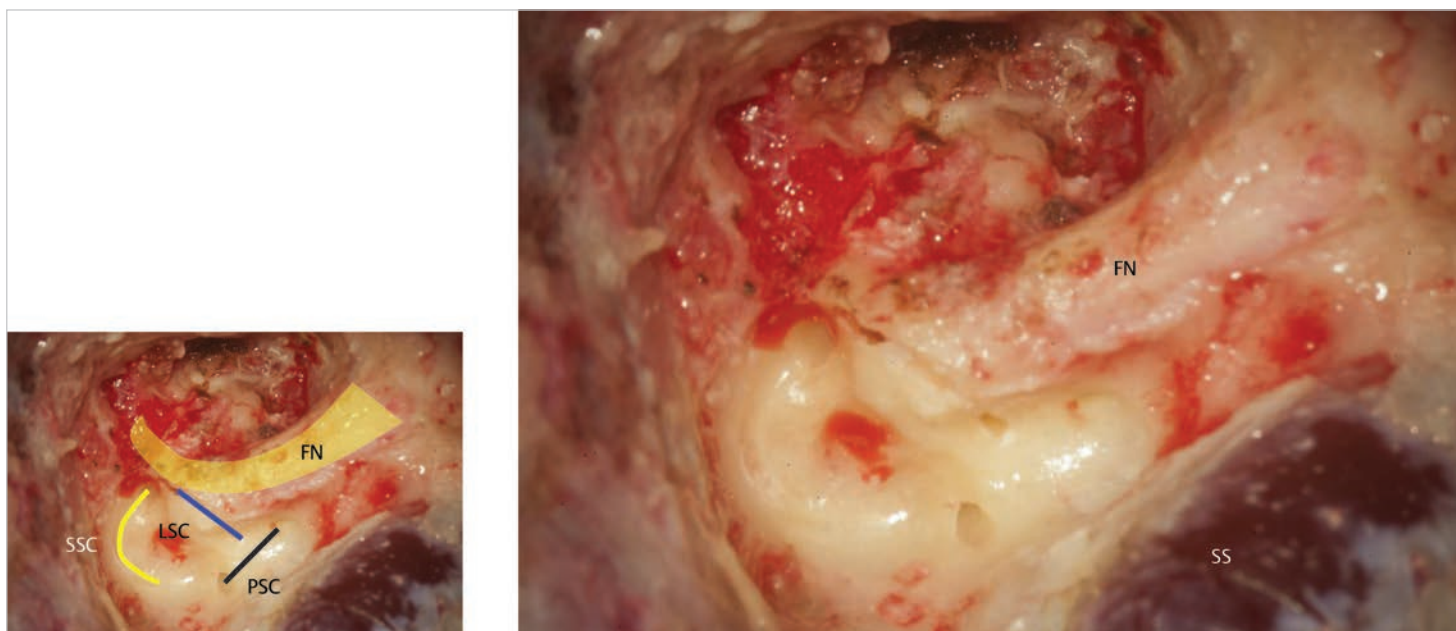


Fig. 14.386 Three semicircular canals are seen. FN, facial nerve; LSC, lateral semicircular canal; PSC, posterior semicircular canal; SS, sigmoid sinus; SSC, superior semicircular canal.

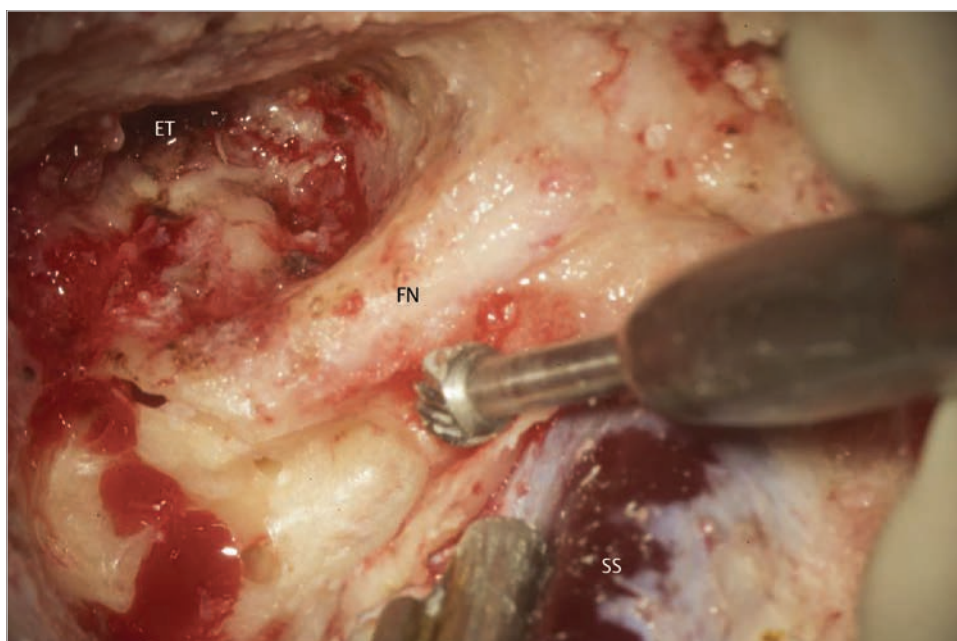


Fig. 14.387 To gain access to the petrous apex, the bone under the facial nerve is drilled. ET, eustachian tube; FN, facial nerve; SS, sigmoid sinus.

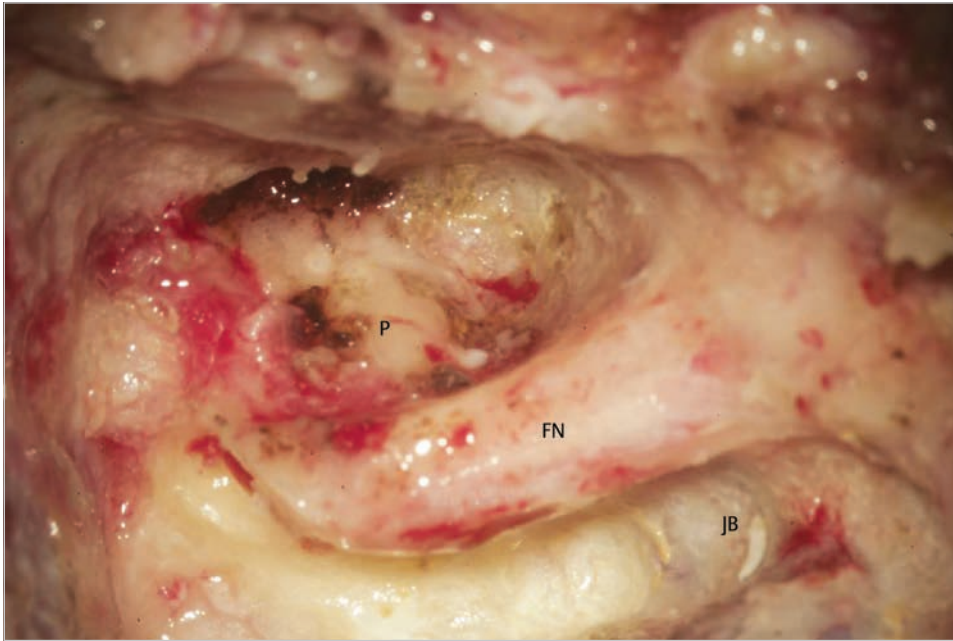


Fig. 14.388 Medially to the facial nerve, the jugular bulb is started to be seen as an area of bluish color. FN, facial nerve; JB, jugular bulb; P, promontory.



Fig. 14.389 Drilling of the hypotympanic cells is carried out with a diamond burr to expose the most lateral part of cholesteatoma. FN, facial nerve; P, promontory.

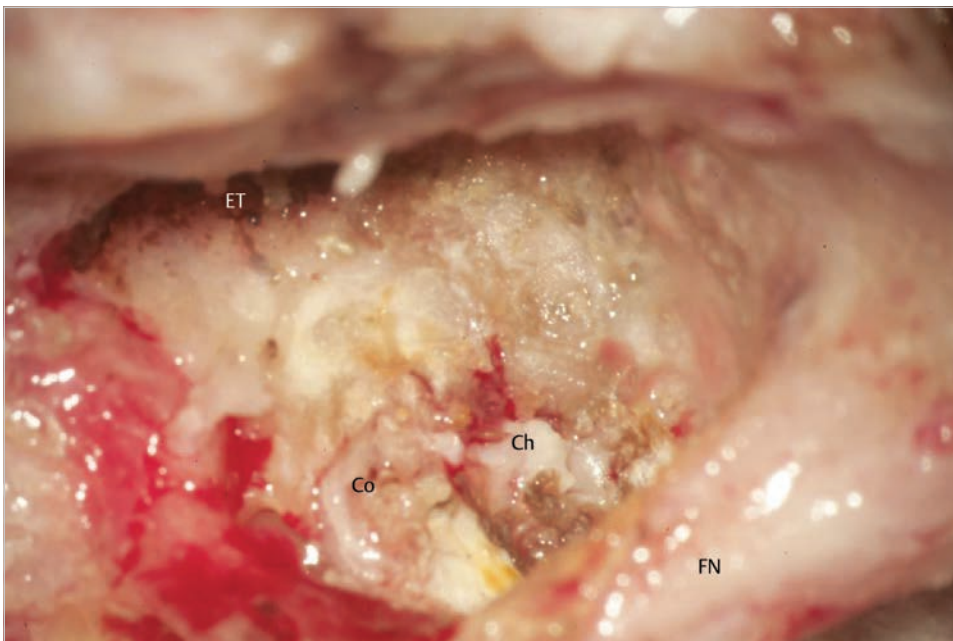


Fig. 14.390 The drilling revealed cholesteatoma infiltrating the medial wall of the tympanic cavity. Drilling is further advanced superiorly, to remove the cochlea. Note that the basal turn of it is totally filled with fibrous tissue. Ch, cholesteatoma; Co, cochlea; ET, eustachian tube; FN, facial nerve.



Fig. 14.391 The cochlea is further drilled, and bone under the facial nerve is removed. A small dissector is introduced through the space created under the facial nerve. The cholesteatoma is located far medially, and the approach needs to be enlarged in all directions. FN, facial nerve.

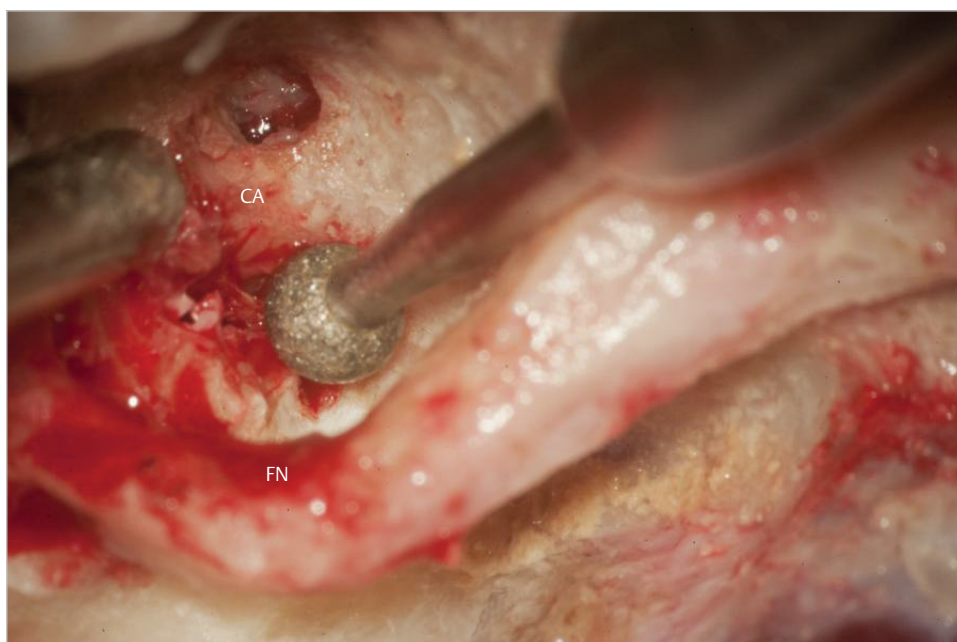


Fig. 14.392 Removal of the bone is advanced medially with a diamond burr. Anteriorly, the carotid artery covered with thin bony shell is identified. In this procedure, care should be taken not to damage the facial nerve with the shaft. CA, carotid artery; FN, facial nerve.



Fig. 14.393 Main part of cholesteatoma filling the petrous apex is started to be seen. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

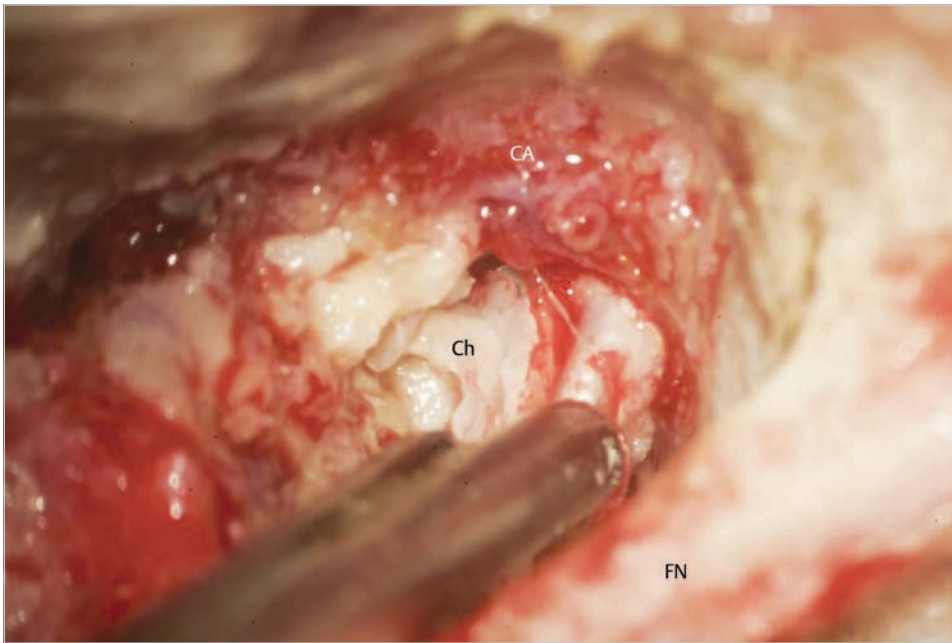


Fig. 14.394 Dissection of cholesteatoma under the carotid artery is carried out. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

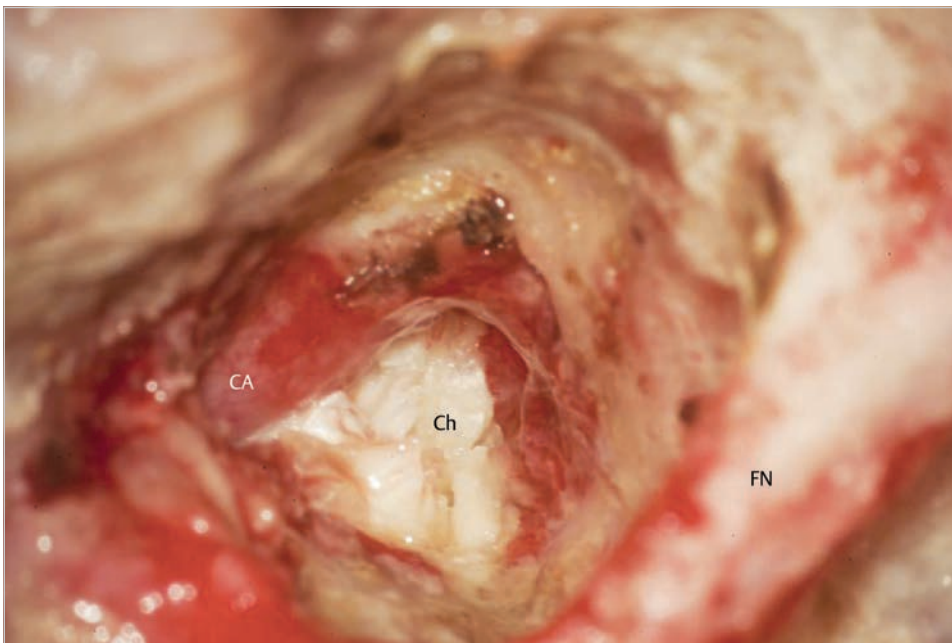


Fig. 14.395 The cholesteatoma reaching under the horizontal segment of the carotid artery is shown. CA, carotid artery, horizontal segment; Ch, cholesteatoma; FN, facial nerve.

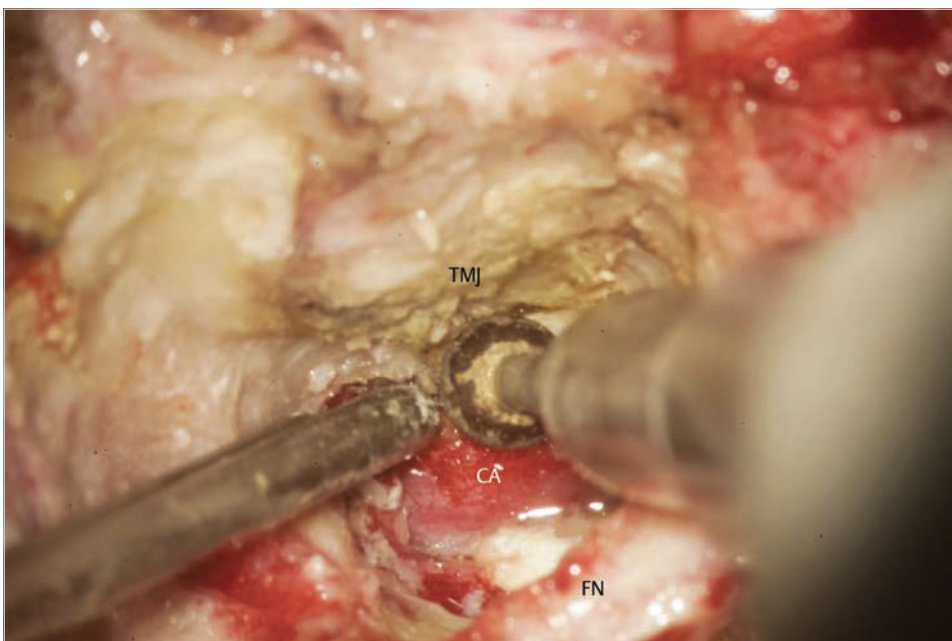


Fig. 14.396 To control the carotid artery better, the anterior wall of the external auditory canal is removed and the temporomandibular joint is exposed with the diamond burr. CA, carotid artery; FN, facial nerve; TMJ, temporomandibular joint.

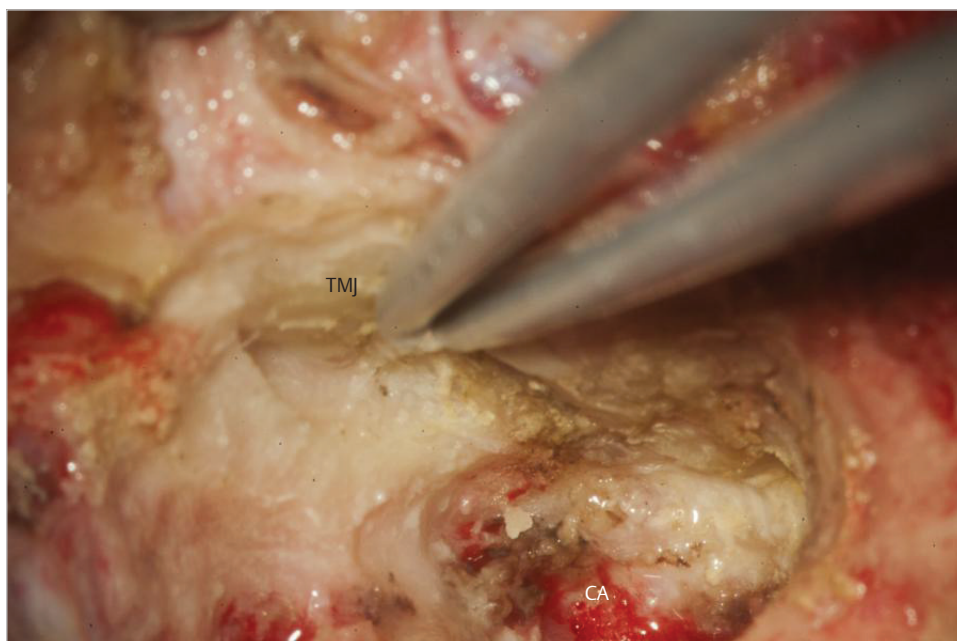


Fig. 14.397 The posterior face of the temporomandibular joint is completely exposed and shrunk with bipolar coagulation. CA, carotid artery; TMJ, temporomandibular joint.

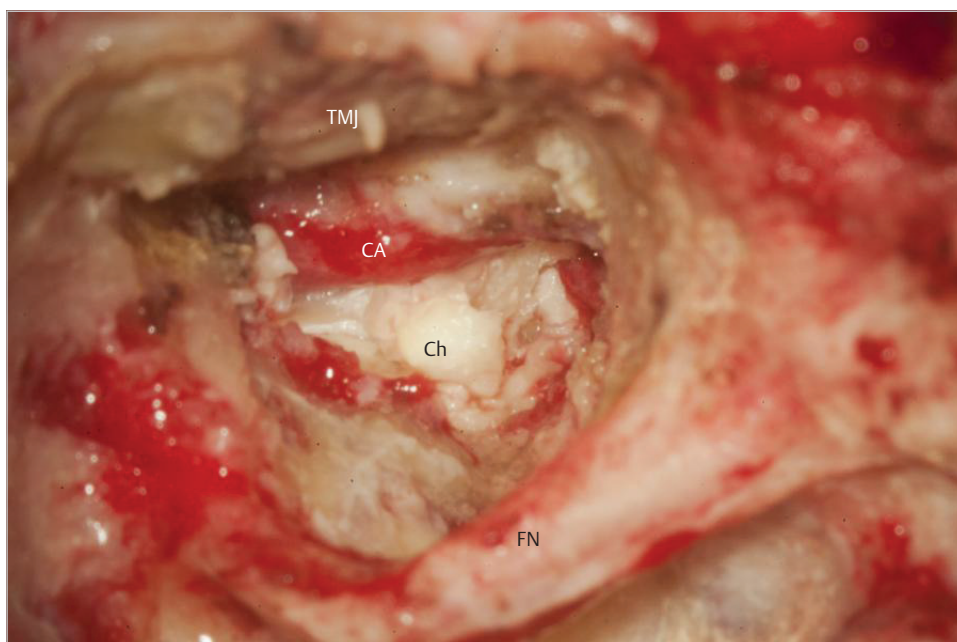


Fig. 14.398 The cholesteatoma is seen under the carotid artery, anteriorly to the internal auditory canal. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; TMJ, temporomandibular joint.

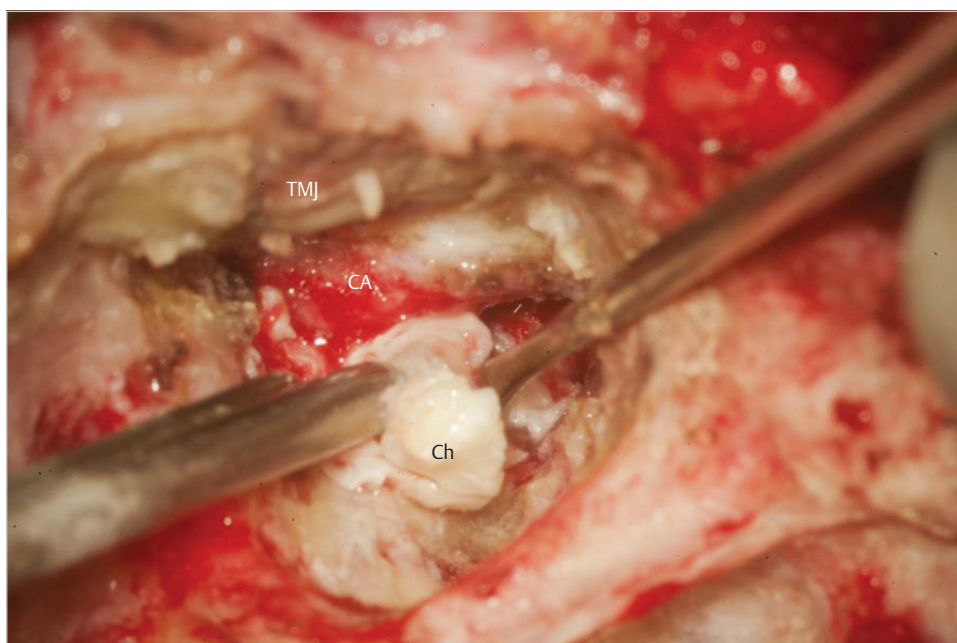


Fig. 14.399 From time to time, debris needs to be removed to see better the underlying structures and to facilitate dissection of the matrix. CA, carotid artery; Ch, cholesteatoma; TMJ, temporomandibular joint.

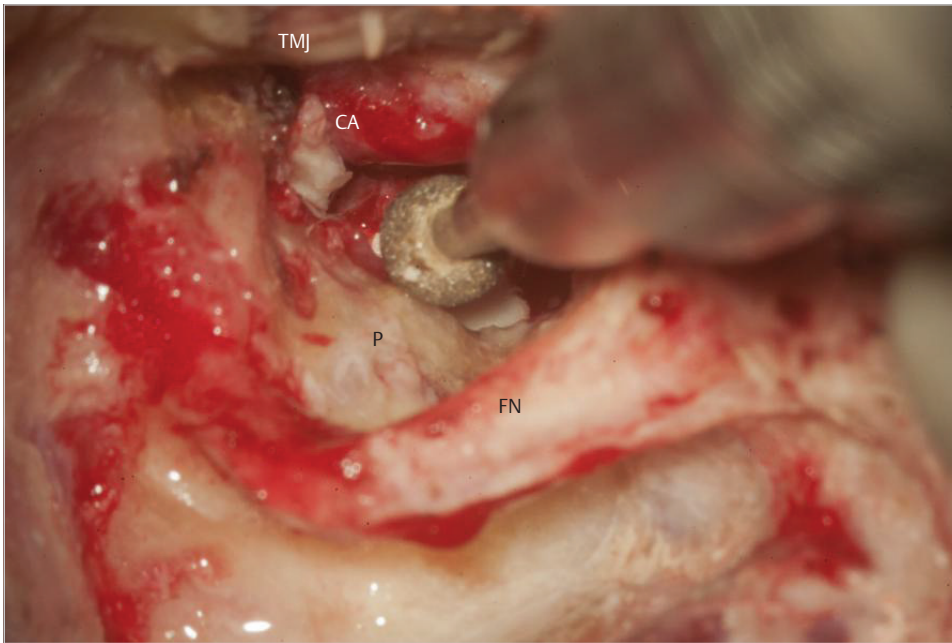


Fig. 14.400 The bone anteriorly to the internal auditory canal is removed with a large diamond burr taking care not to insult the contents of the internal auditory canal. CA, carotid artery; FN, facial nerve; P, promontory; TMJ, temporomandibular joint.

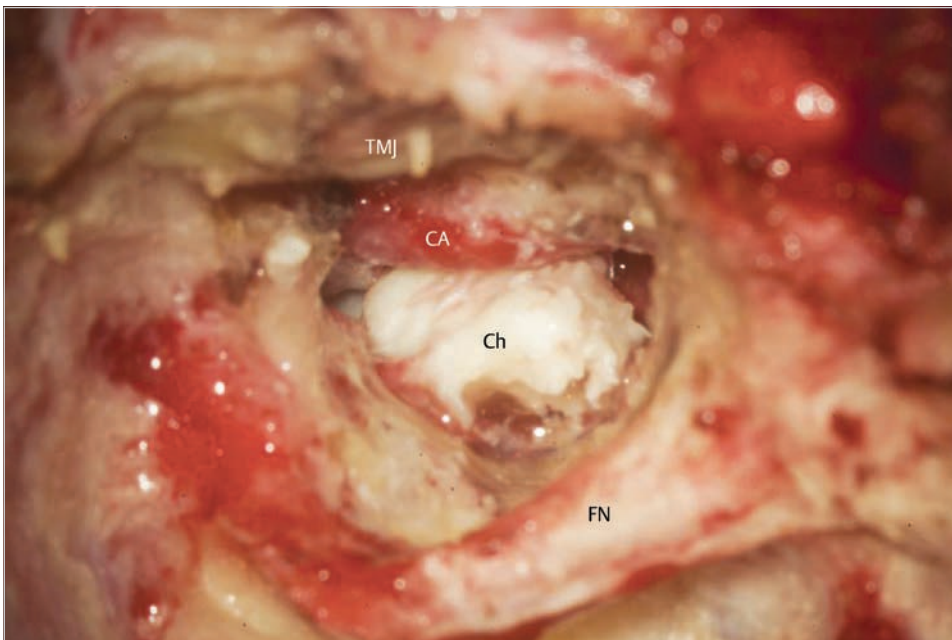


Fig. 14.401 Debris of the cholesteatoma is evacuated from the petrous apex. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; TMJ, temporomandibular joint.

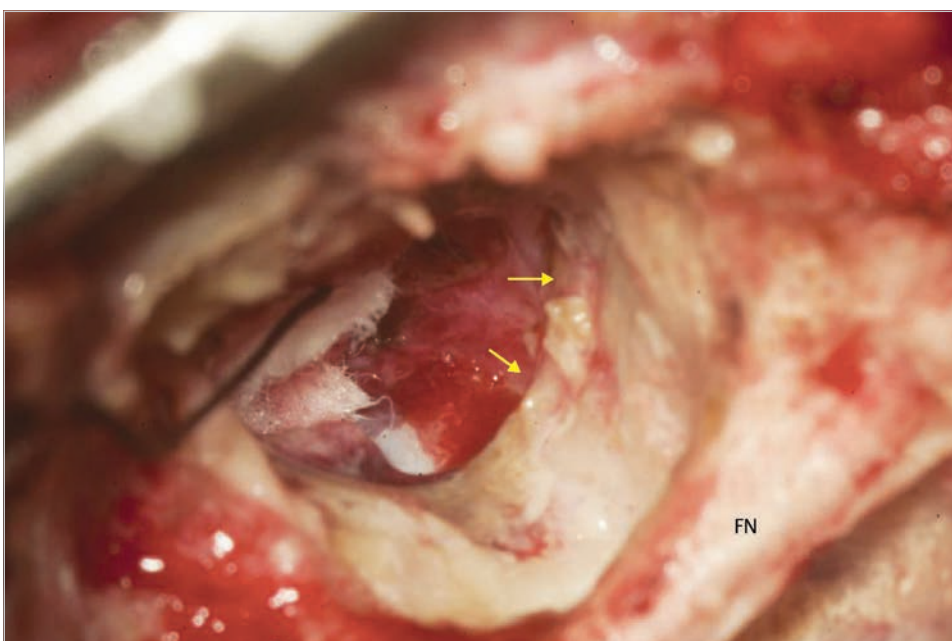


Fig. 14.402 The glossopharyngeal nerve located in the anterosuperior part of the jugular foramen, coursing oblique from superomedial to inferolateral, is seen (arrows). The vagal nerve is located just beneath. Meticulous care should be taken not to damage these nerves during the bone removal anteriorly to the jugular bulb. Damage of these nerves may cause severe swallowing disturbance especially in elderly. FN, facial nerve.



Fig. 14.403 The cholesteatoma is dissected from the posterior fossa dura. Some matrix remains over the inferior petrosal sinus that connects the jugular bulb with the cavernous sinus. FN, facial nerve; IPS, inferior petrosal sinus.

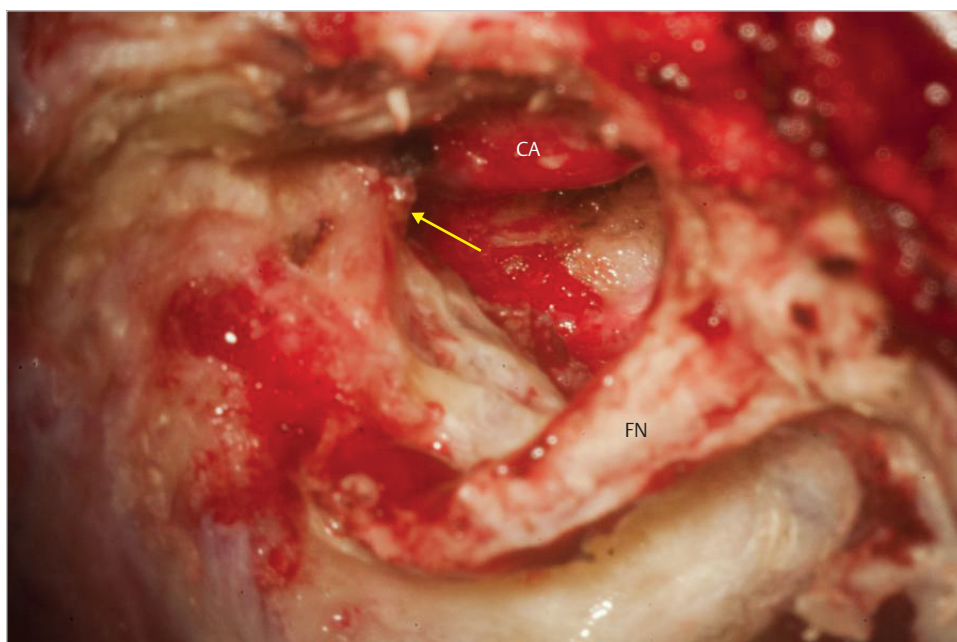


Fig. 14.404 The majority of cholesteatoma is removed from the petrous apex, but the bone covering the area (*arrow*) limits access to the superior border of the cholesteatoma and the horizontal segment of the carotid artery. CA, carotid artery; FN, facial nerve.

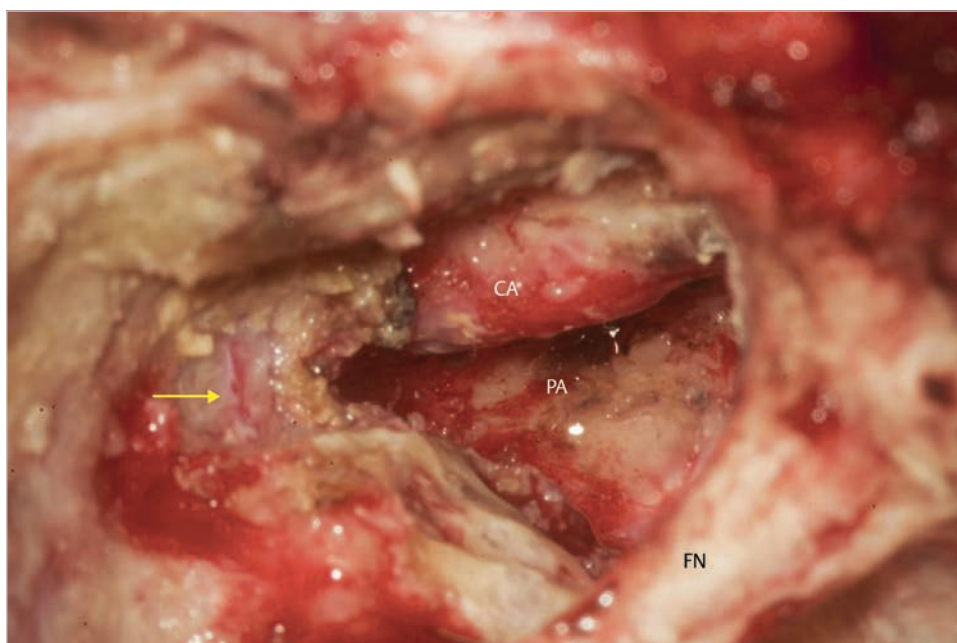


Fig. 14.405 The great superficial petrosal nerve (*arrow*) branches anteriorly from the geniculate ganglion of the facial nerve forms the superior limit of this drilling, since damaging its vasculature will cause complete facial palsy with incomplete recovery. Some bone under the nerve should be removed in this situation to gain access to the petrous apex. CA, carotid artery; FN, facial nerve; PA, petrous apex.

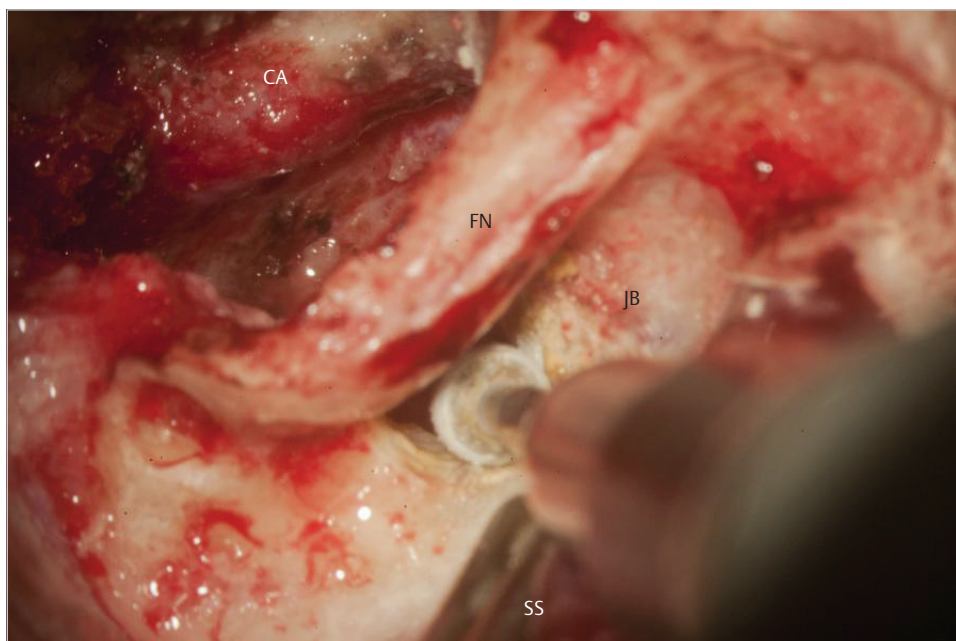


Fig. 14.406 The subfacial approach removing the bone under the facial nerve, between the internal auditory canal and the jugular bulb is carried out. During this procedure, the cochlear aqueduct is cut to cause liquorrhea from subarachnoid space. The cochlear aqueduct serves for a good landmark of lower cranial nerves, since it branches from the superior border of the pars nervosa of the jugular foramen, and the glossopharyngeal nerve courses just below it. CA, carotid artery; FN, facial nerve; JB, jugular bulb; SS, sigmoid sinus.

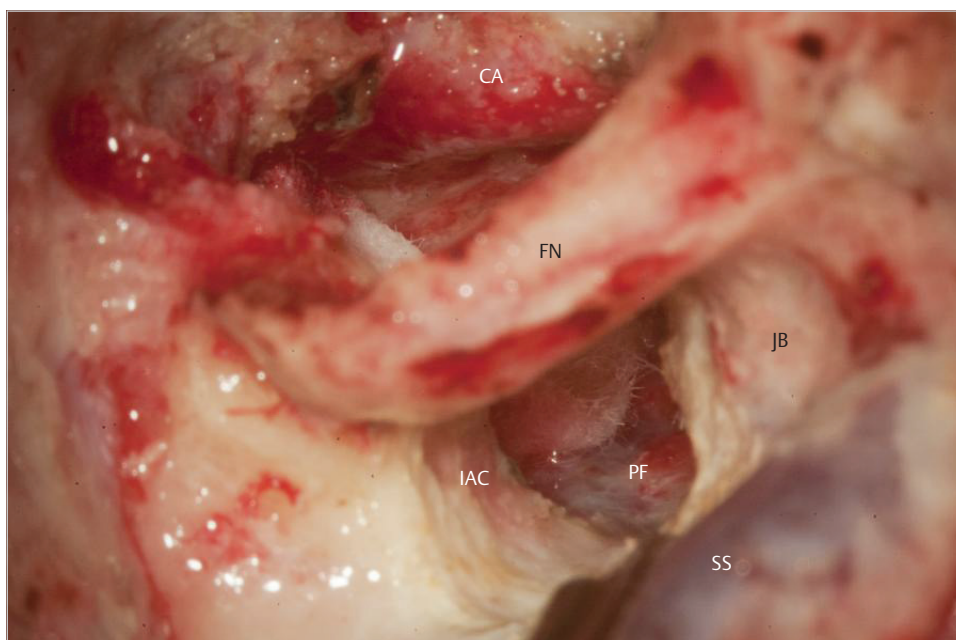


Fig. 14.407 During this procedure, the cochlear aqueduct arising from the jugular foramen to reach the basal turn of the cochlea is cut, and liquorrhea from subarachnoid space follows. CA, carotid artery; FN, facial nerve; IAC, internal auditory canal; JB, jugular bulb; PF, posterior fossa dura; SS, sigmoid sinus.

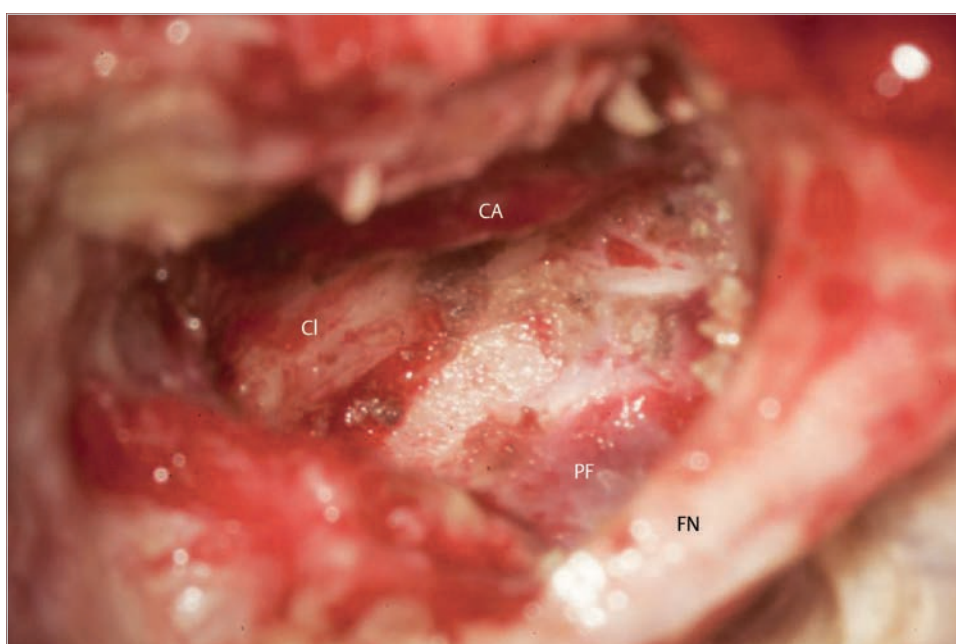


Fig. 14.408 The area of clivus after removal of the cholesteatoma is shown. CA, carotid artery; Cl, clivus; FN, facial nerve; PF, posterior fossa dura.

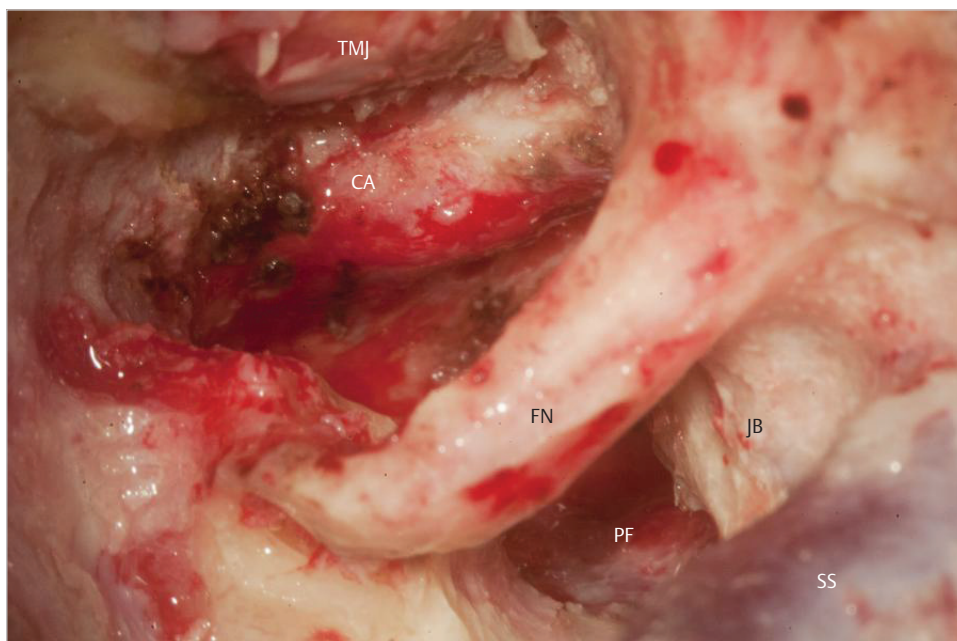


Fig. 14.409 The final shape of the cavity is shown. CA, carotid artery; FN, facial nerve; JB, jugular bulb; PF, posterior fossa dura; SS, sigmoid sinus; TMJ, temporomandibular joint.

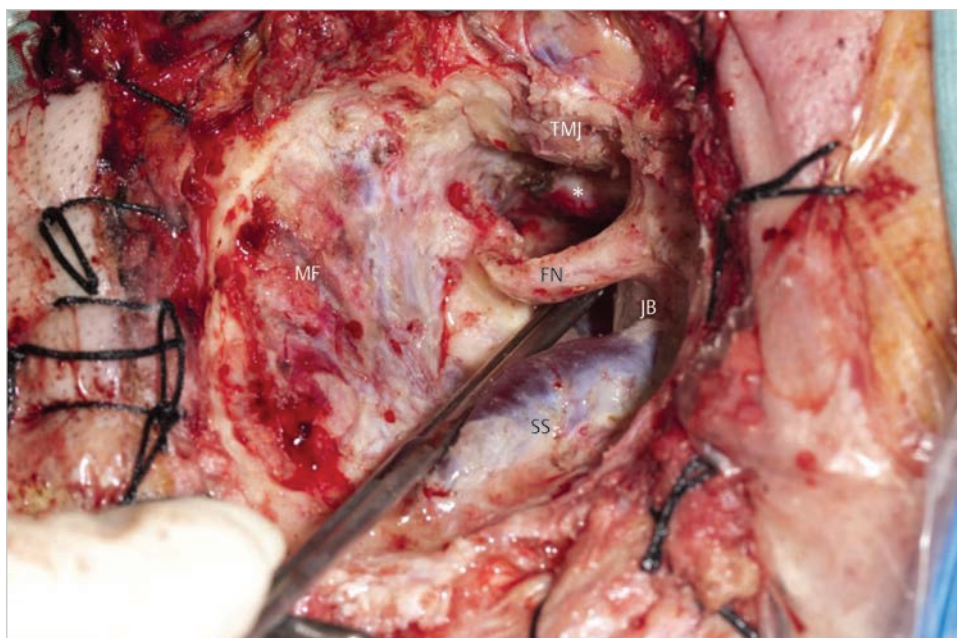


Fig. 14.410 Note the wide exposure of the structures in the temporal bone to access to the petrous apex safely. Uncovering of the sigmoid sinus greatly enhances access to the deep area by simply pressing it. *, carotid artery; FN, facial nerve; JB, jugular bulb; MF, middle fossa dura; SS, sigmoid sinus; TMJ, temporomandibular joint.

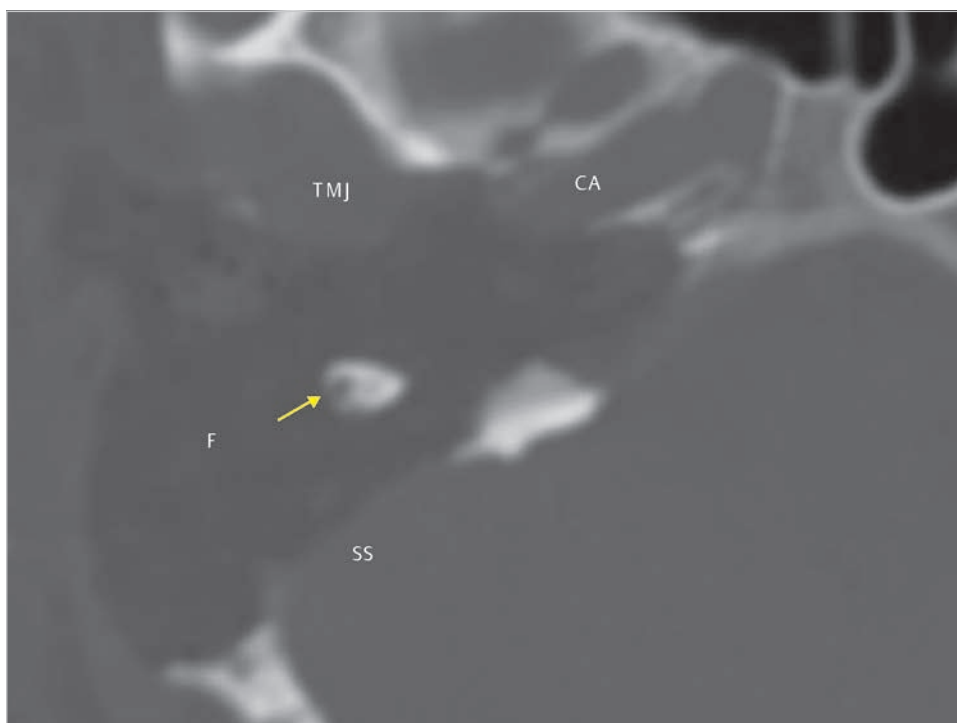


Fig. 14.411 The postoperative CT shows extensive removal of bone from the petrous apex, exposing the posterolateral face of the carotid artery and the posterior face of the temporomandibular joint. The facial nerve running in the fallopian canal is seen (arrow). CA, carotid artery; F, abdominal fat; SS, sigmoid sinus; TMJ, temporomandibular joint.

Case 14.17 (Right Ear)

See ▶Fig. 14.412, ▶Fig. 14.413, ▶Fig. 14.414, ▶Fig. 14.415, ▶Fig. 14.416, ▶Fig. 14.417, ▶Fig. 14.418, ▶Fig. 14.419, ▶Fig. 14.420, ▶Fig. 14.421, ▶Fig. 14.422, ▶Fig. 14.423, ▶Fig. 14.424, ▶Fig. 14.425.

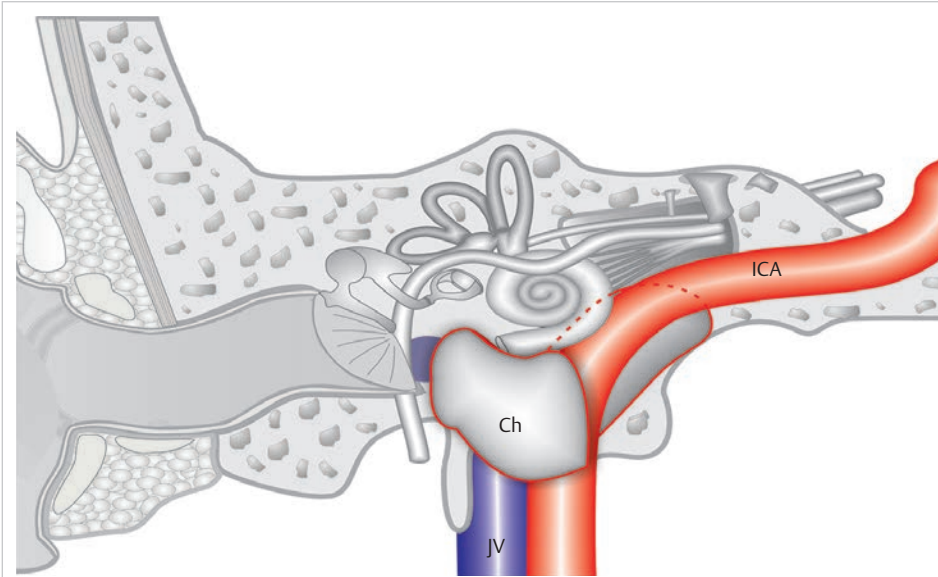


Fig. 14.412 A case of congenital infralabyrinthine–apical petrous bone cholesteatoma with erosion of the internal auditory canal and the jugular foramen. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

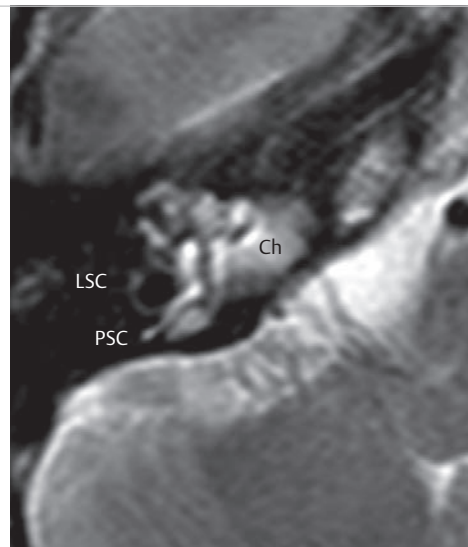
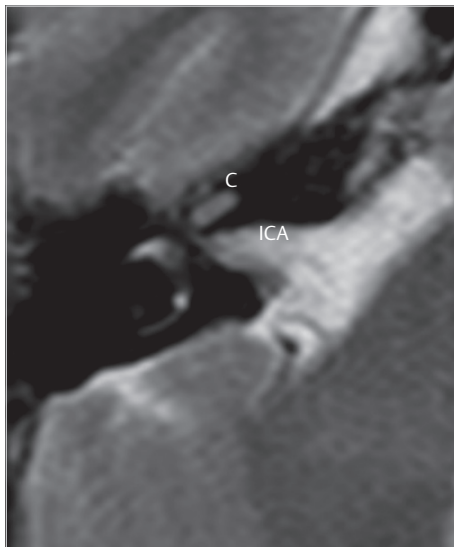


Fig. 14.413 The T2-weighted image MRI shows no pathology in the superior part of the temporal bone including the internal auditory canal (a). Petrous apex lesion located medially to the labyrinth starts to appear one slice inferiorly to it (b). Semicircular canals are identified in this slice. C, cochlea; Ch, cholesteatoma; ICA, internal carotid artery; LSC, lateral semicircular canal; PSC, posterior semicircular canal.

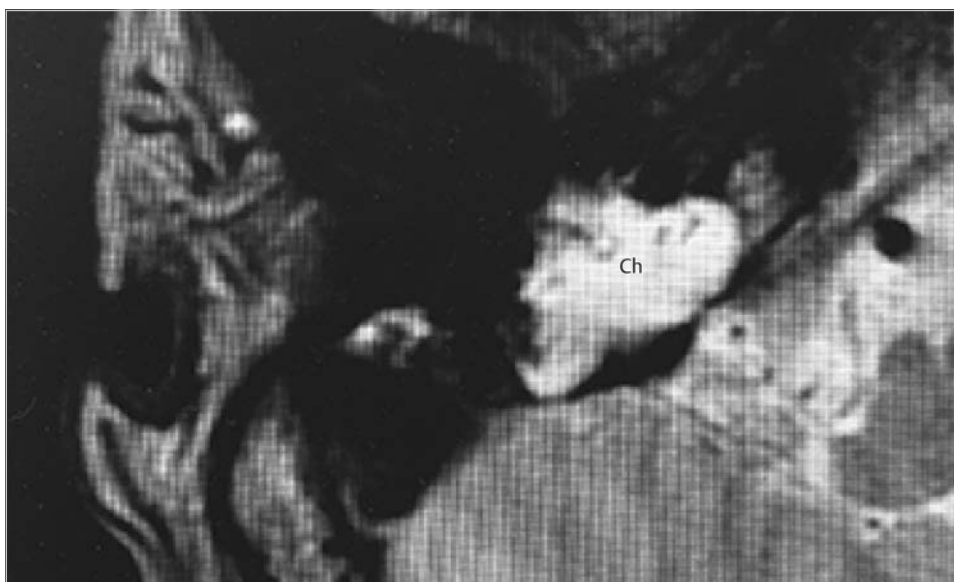


Fig. 14.414 The more caudal section demonstrates far medial extension of cholesteatoma. Ch, cholesteatoma.

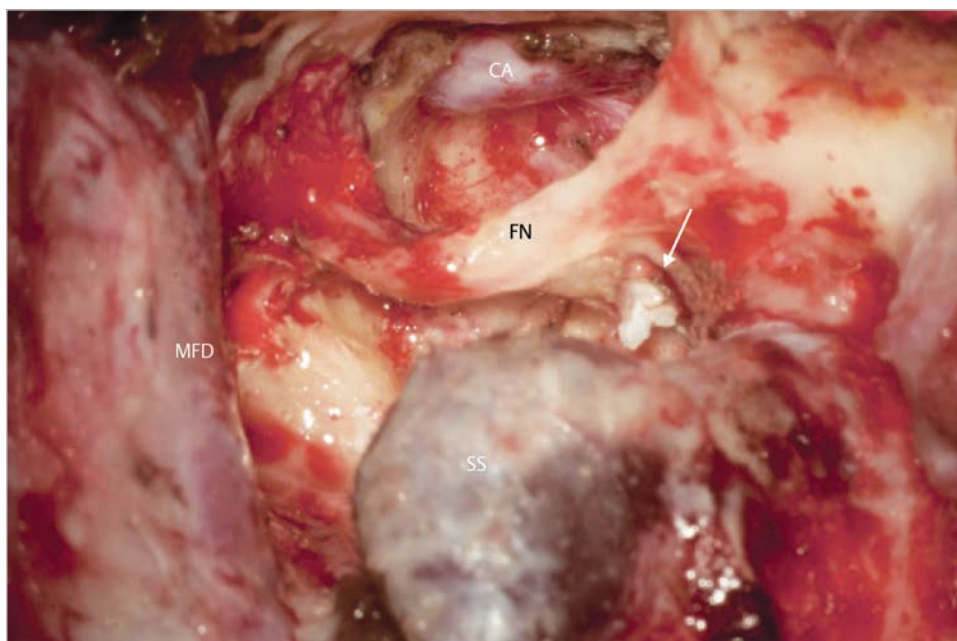


Fig. 14.415 To approach the petrous apex region, the middle and the posterior fossae dura are uncovered, and the otic capsule is removed except the most anterosuperior part embedding the tympanic and the labyrinthine segments of the facial nerve. The majority of cholesteatoma has already been removed from the petrous apex region except the area of the jugular bulb (*arrow*). Note the protruded sigmoid sinus limit the view to the area. CA, carotid artery; FN, facial nerve; MFD, middle fossa dura; SS, sigmoid sinus.

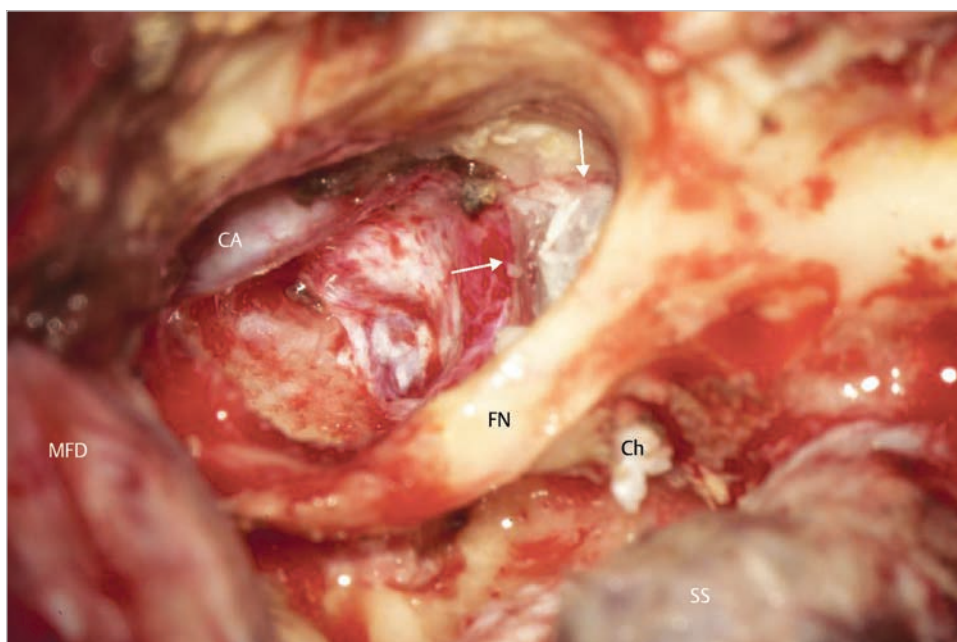


Fig. 14.416 In higher magnification and viewed anteriorly, the area of the jugular bulb is covered with cholesteatoma matrix (*arrows*). CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura; SS, sigmoid sinus.

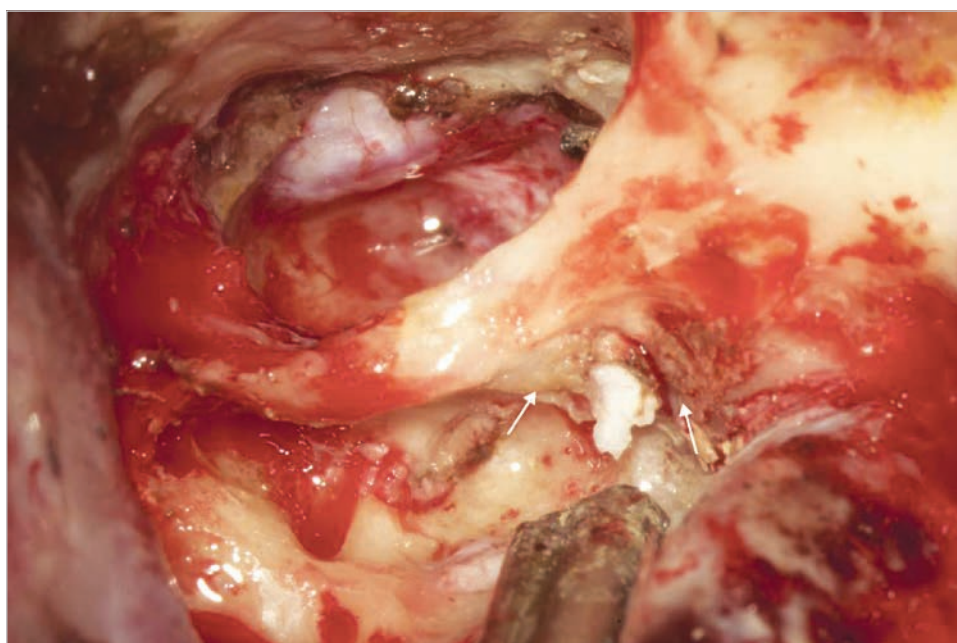


Fig. 14.417 To expose the area of the jugular bulb, bone under the facial nerve should be removed (*arrows*).

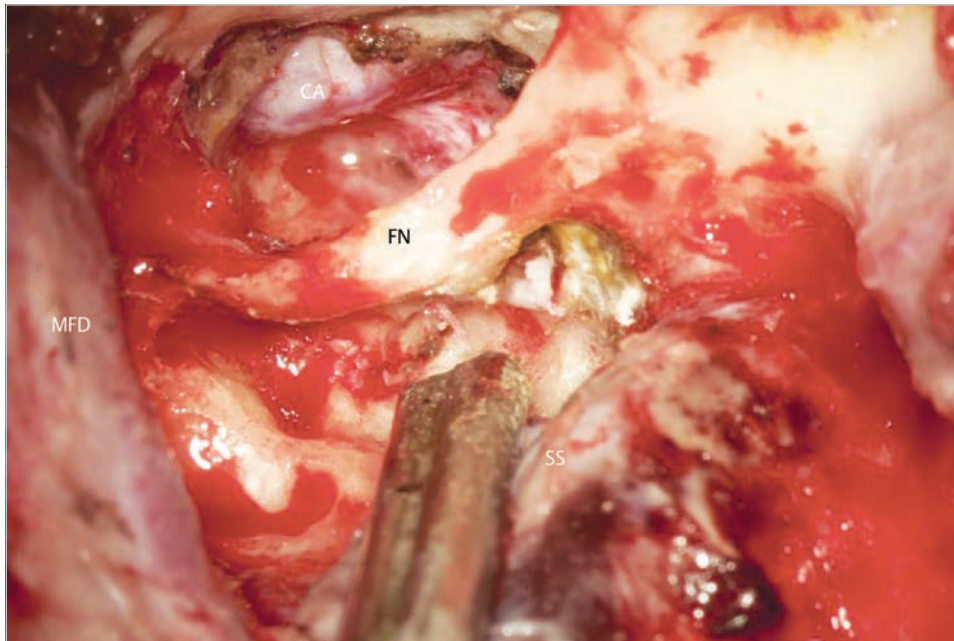


Fig. 14.418 The bone covering the area of the jugular bulb is removed. Note the importance of uncovering of the protruded sigmoid sinus for cholesteatoma dissection from the area under the facial nerve. CA, carotid artery; FN, facial nerve; MFD, middle fossa dura; SS, sigmoid sinus.

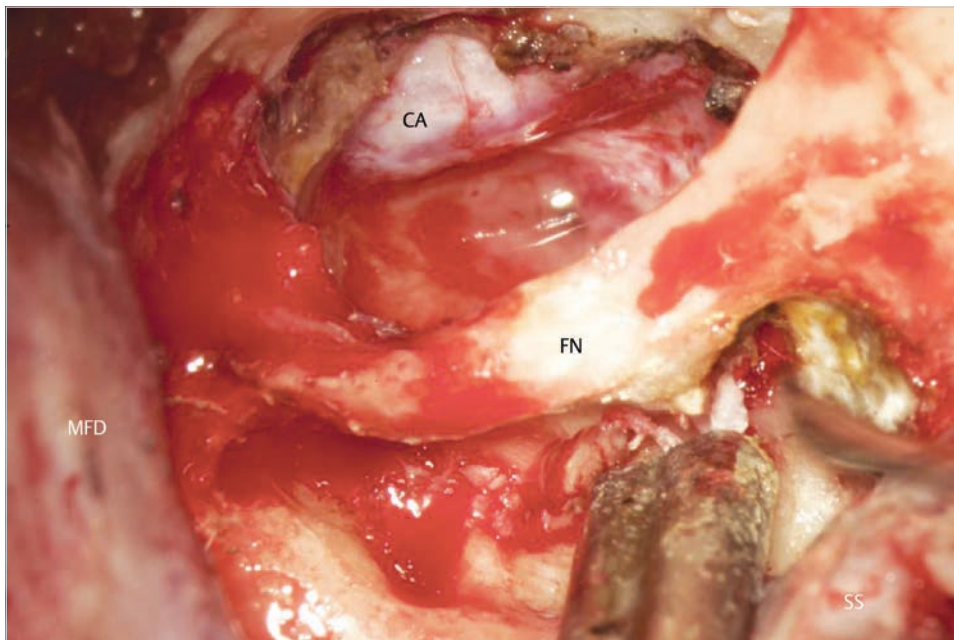


Fig. 14.419 Cholesteatoma covering the jugular bulb is started to be dissected from the approach established under the facial nerve. CA, carotid artery; FN, facial nerve; MFD, middle fossa dura; SS, sigmoid sinus.



Fig. 14.420 Cleaning of the matrix covering posterior part of the jugular bulb is accomplished. JB, jugular bulb.

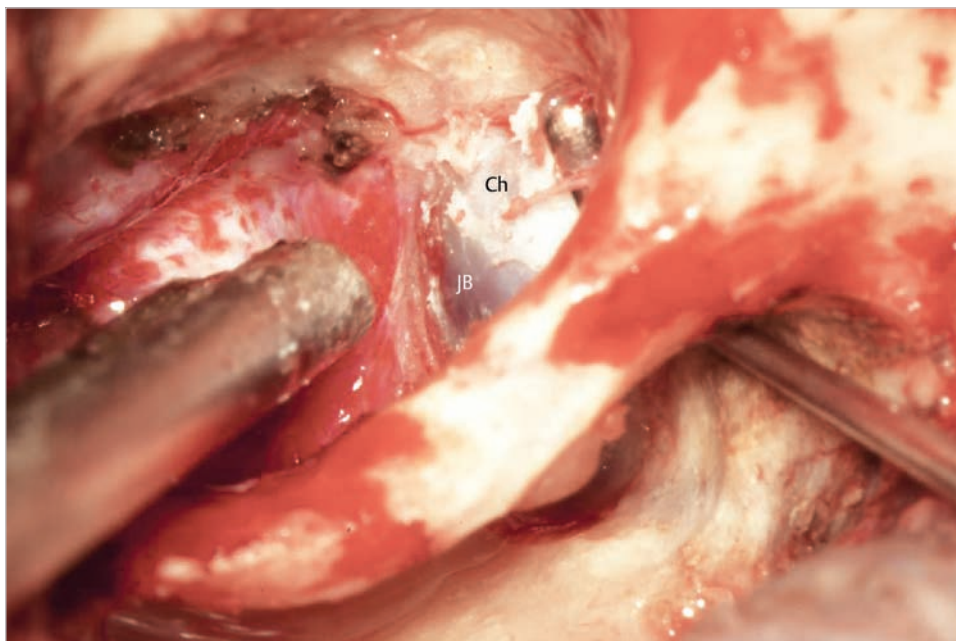


Fig. 14.421 The matrix covering the anterior part of the jugular bulb is dissected with a small dissector passing under the fallopian canal. Ch, cholesteatoma; JB, jugular bulb.

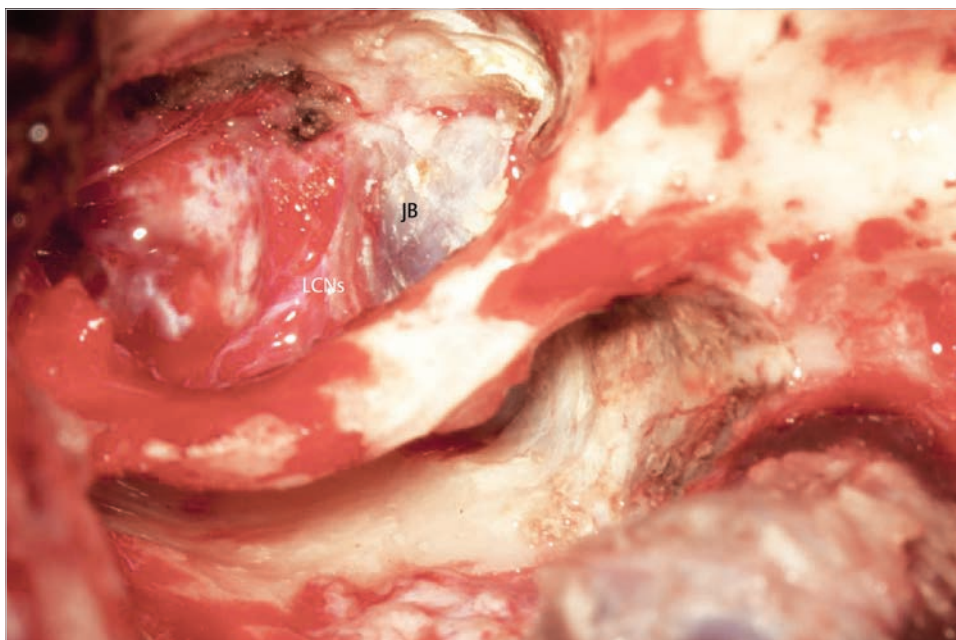


Fig. 14.422 Dissection of the matrix from the jugular bulb is accomplished. Bundle of the lower cranial nerves passing the pars nervosa of the jugular foramen can be identified just anteriorly to the jugular bulb. JB, jugular bulb; LCNs, lower cranial nerves.

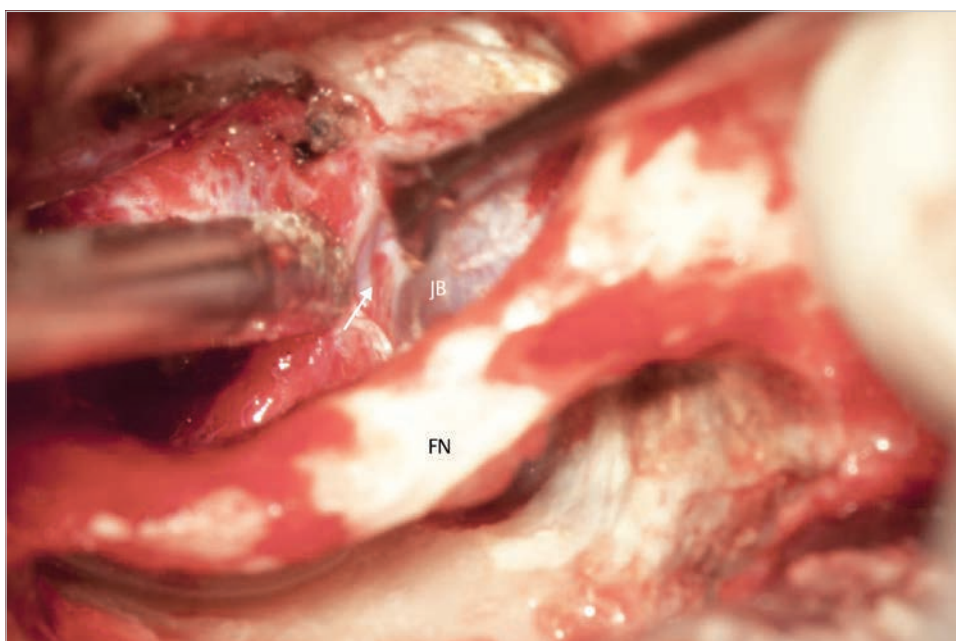


Fig. 14.423 The top of the jugular bulb is gently pushed inferiorly. The glossopharyngeal nerve running just anteriorly to the bulb can be identified (arrow). FN, facial nerve; JB, jugular bulb.

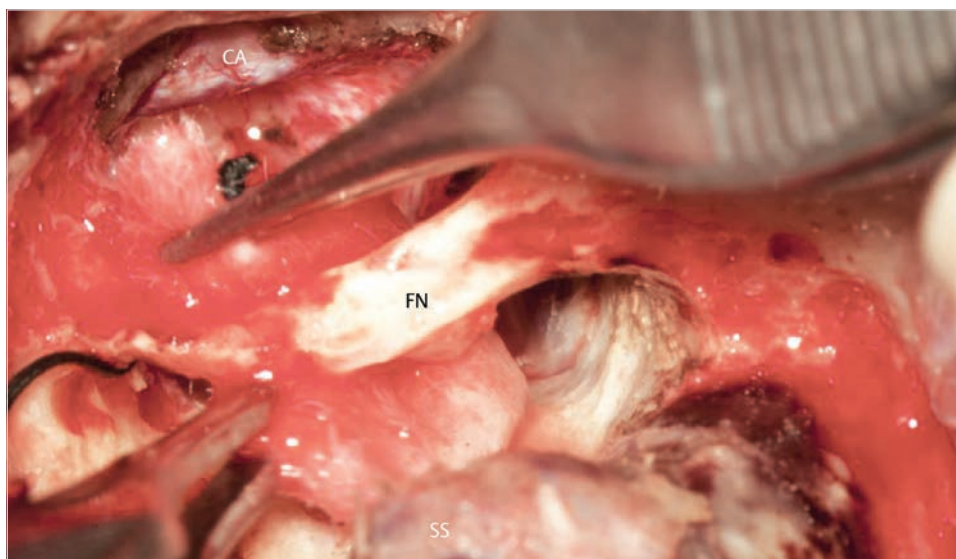


Fig. 14.424 The suspicious area for residual cholesteatoma under the fallopian canal is intensively scrubbed with cottonoid. Following procedures include closure of the eustachian tube and obliteration of the cavity with abdominal fat. CA, carotid artery; FN, facial nerve; SS, sigmoid sinus.



Fig. 14.425 Postoperative CT shows extensive removal of bone from the inferior part of the temporal bone. Partially removed cochlea with two segments of the facial nerve, the labyrinthine (white arrow) and the tympanic (yellow arrow), can be seen. C, cochlea.

Case 14.18 (Right Ear)

See ▶ Fig. 14.426, ▶ Fig. 14.427, ▶ Fig. 14.428, ▶ Fig. 14.429, ▶ Fig. 14.430, ▶ Fig. 14.431, ▶ Fig. 14.432, ▶ Fig. 14.433, ▶ Fig. 14.434, ▶ Fig. 14.435, ▶ Fig. 14.436, ▶ Fig. 14.437, ▶ Fig. 14.438, ▶ Fig. 14.439, ▶ Fig. 14.440, ▶ Fig. 14.441, ▶ Fig. 14.442, ▶ Fig. 14.443, ▶ Fig. 14.444, ▶ Fig. 14.445, ▶ Fig. 14.446, ▶ Fig. 14.447, ▶ Fig. 14.448, ▶ Fig. 14.449, ▶ Fig. 14.450, ▶ Fig. 14.451, ▶ Fig. 14.452.

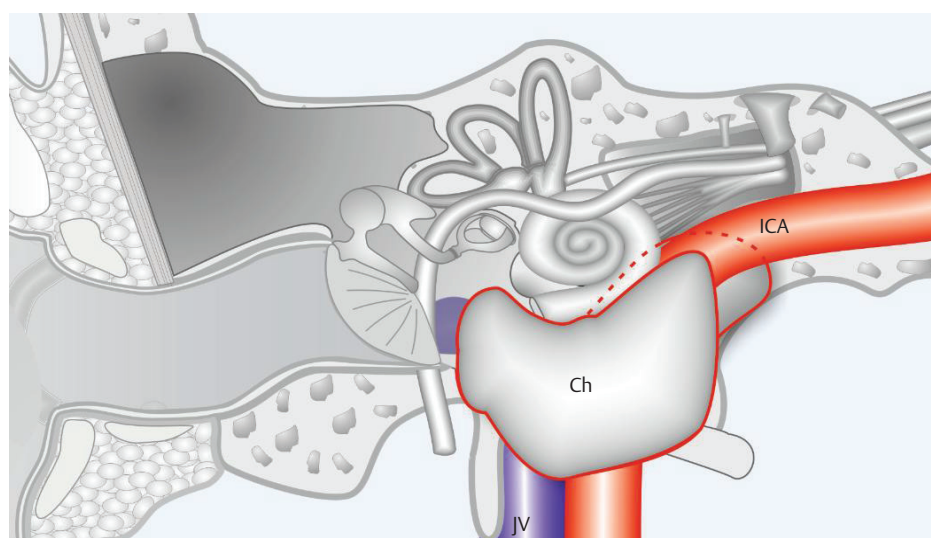


Fig. 14.426 A case of infralabyrinthine apical petrous bone cholesteatoma after canal wall up tympanoplasty eroding the internal auditory canal and the jugular foramen. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

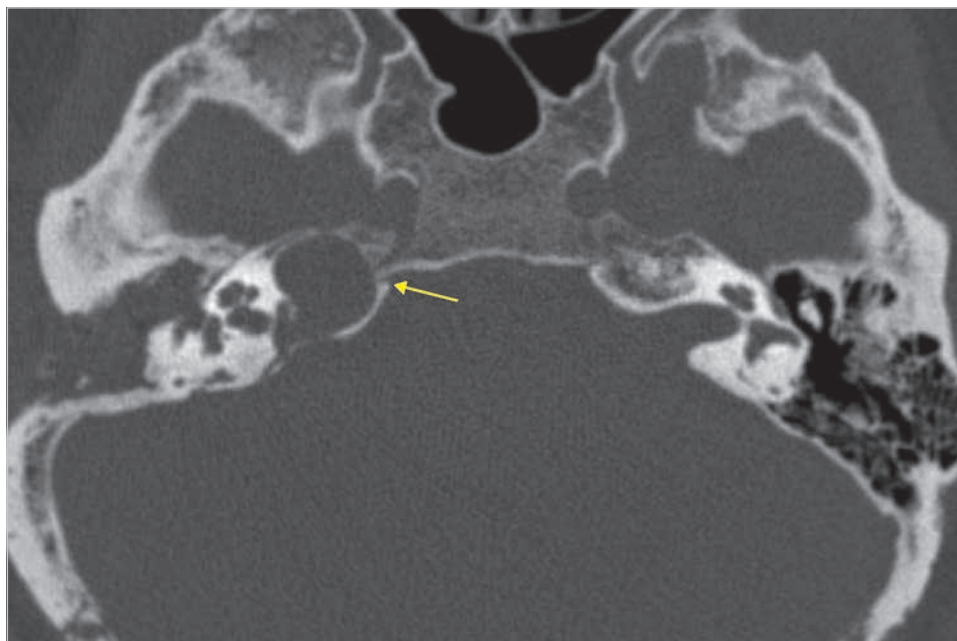


Fig. 14.427 The patient underwent middle ear surgery including mastoidectomy elsewhere. Radiologic examination revealed large petrous bone cholesteatoma in the right petrous apex, reaching the junction of the petrous bone and the clivus (*arrow*).

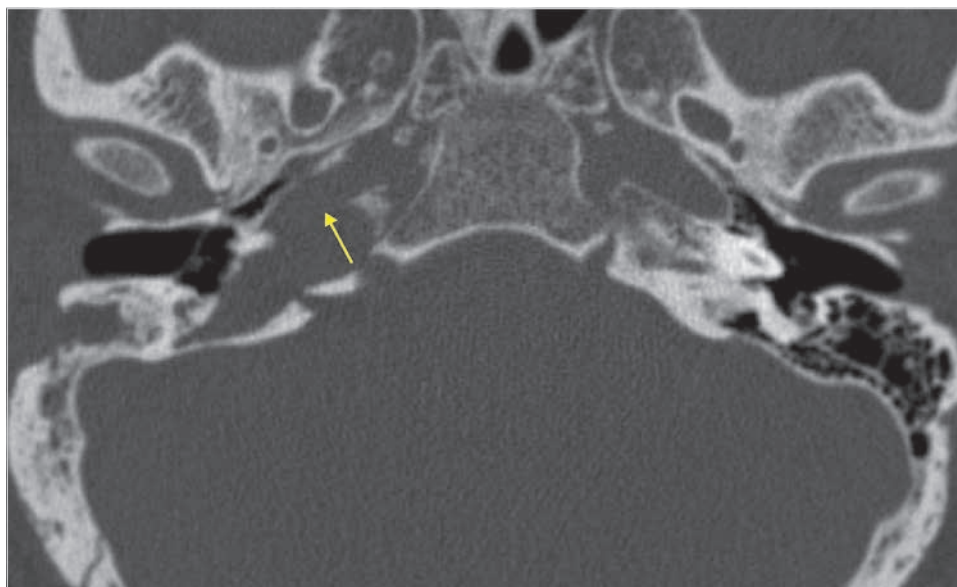


Fig. 14.428 The carotid canal is eroded by the cholesteatoma (*arrow*).



Fig. 14.429 The T2-weighted MRI shows compression of contents in the internal auditory canal.

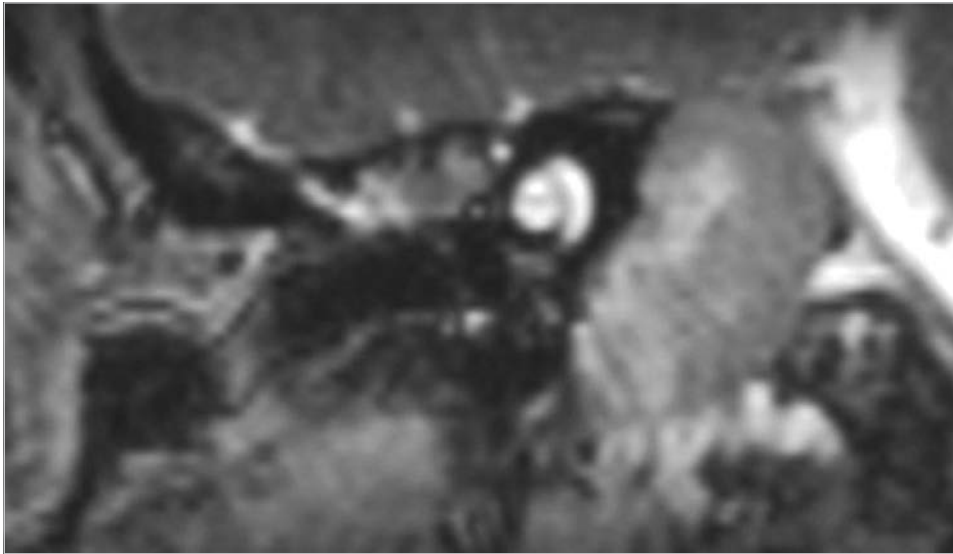


Fig. 14.430 The coronal MRI image shows cholesteatoma occupying the petrous apex.

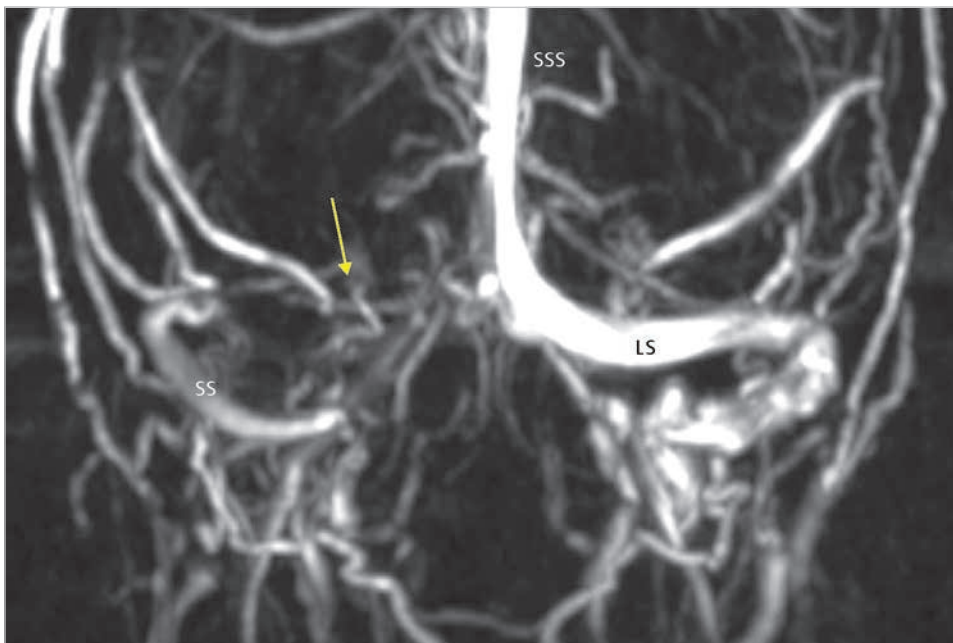


Fig. 14.431 The preoperative MR venography shows interruption of the ipsilateral lateral sinus (*arrow*). Thrombosis of the lateral sinus probably due to former infection affecting the sigmoid sinus is diagnosed. LS, lateral sinus; SS, sigmoid sinus; SSS, superior sagittal sinus.

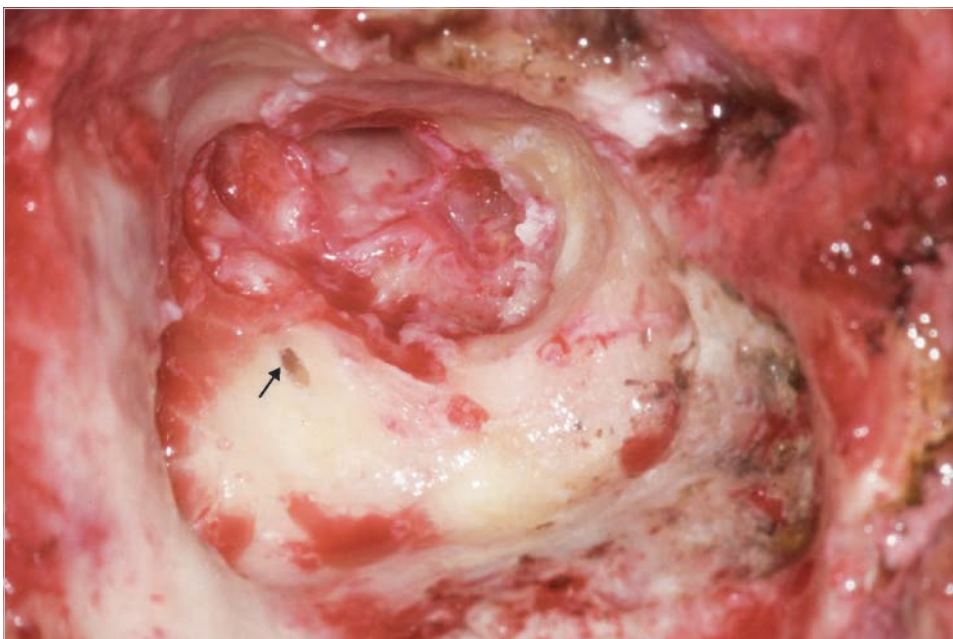


Fig. 14.432 Middle fossa dura and the sigmoid sinus are skeletonized. The labyrinthectomy is started from removal of the lateral semicircular canal. The most lateral part of the lateral semicircular canal is opened (*arrow*).

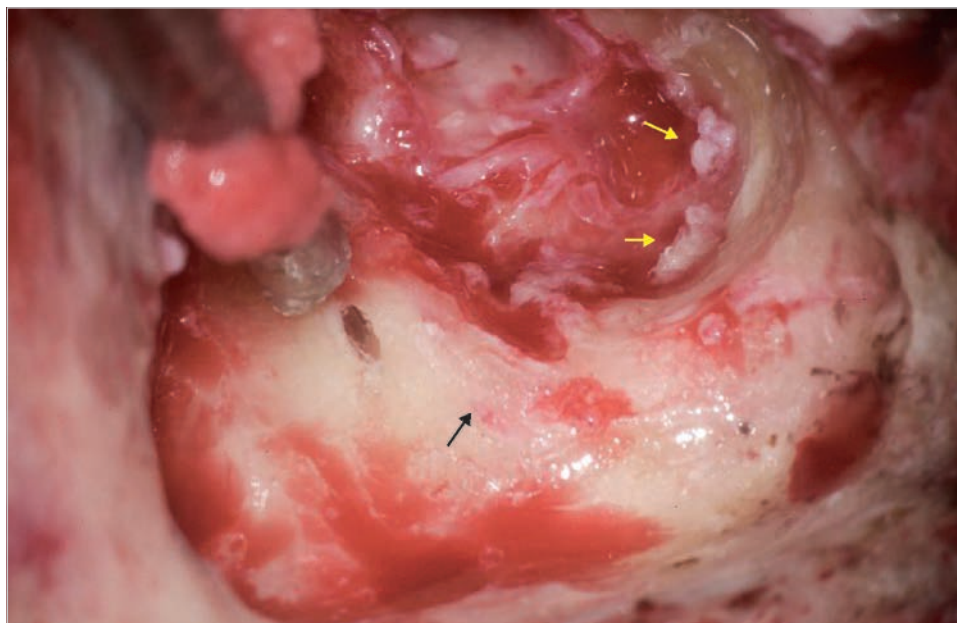


Fig. 14.433 The skin infiltrating the hypotympanic cells is seen (yellow arrows). The pinkish line (black arrow) corresponds to the second genu of the facial nerve. During labyrinthectomy to follow the lateral semicircular canal posteriorly, care should be taken not to damage the facial nerve. The canal goes medial posteriorly, but the nerve comes lateral as seen in this picture. Inattentive drilling trying to follow the lateral semicircular canal may hit the nerve, especially in the cases the nerve makes curve more posteriorly than usual.

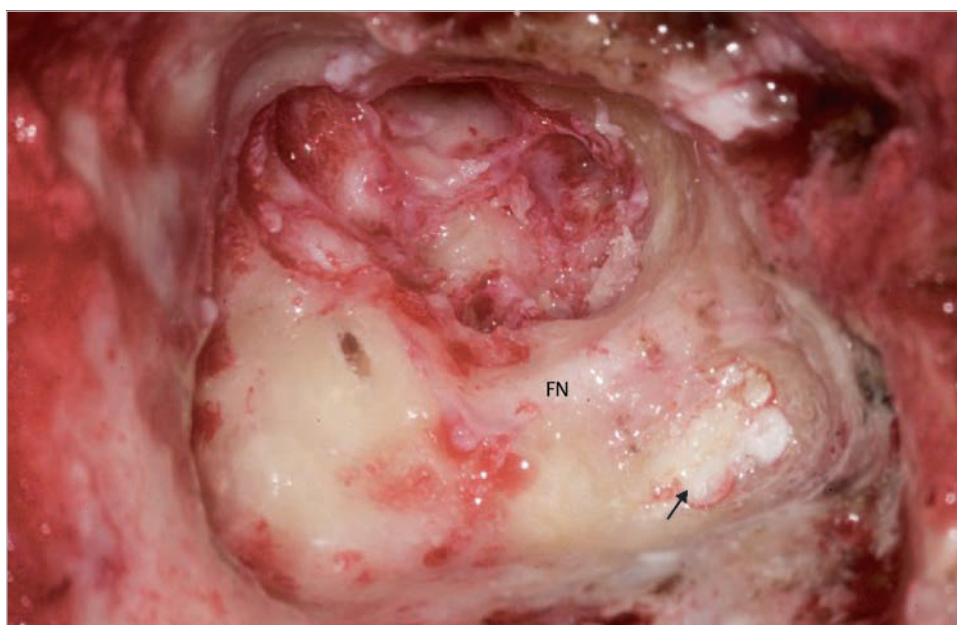


Fig. 14.434 Drilling of the medial wall of the mastoid tip exposed cholesteatoma (arrow). The facial ridge is lowered to the level of the mastoid segment running laterally to the cholesteatoma. FN, facial nerve.

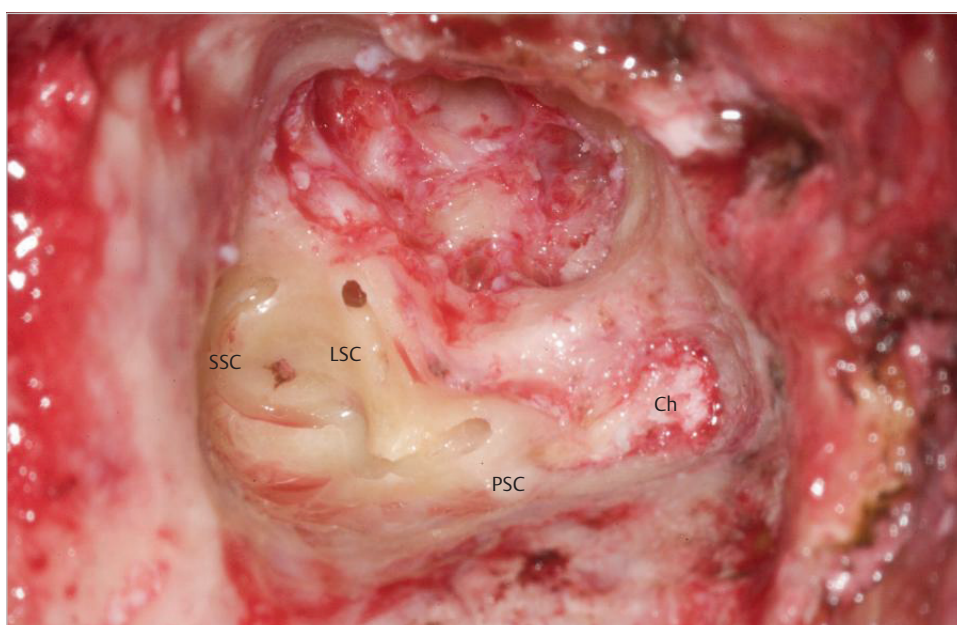


Fig. 14.435 All semicircular canals are opened. Ch, cholesteatoma; LSC, lateral semicircular canal; PSC, posterior semicircular canal; SSC, superior semicircular canal.



Fig. 14.436 The hypotympanic cells are drilled to open the large infralabyrinthine cholesteatoma. Debris is evacuated from both the tympanic cavity and the mastoid. Ch, cholesteatoma; FN, facial nerve.

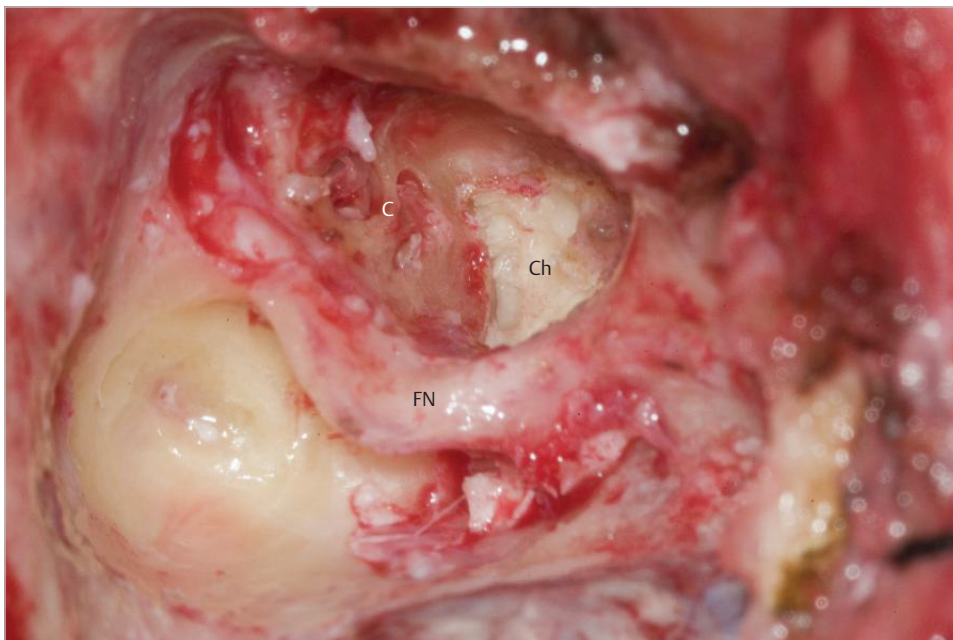


Fig. 14.437 The cochlea is opened to widen the opening in the hypotympanum. C, cochlea; Ch, cholesteatoma; FN, facial nerve.

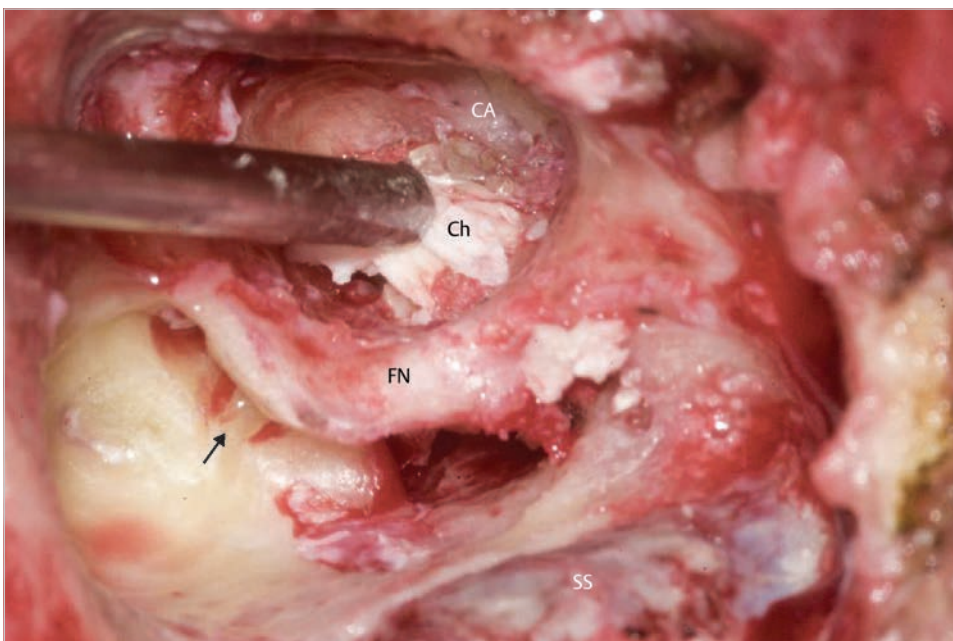


Fig. 14.438 The vertical segment of the carotid artery is started to be seen in the protympanum. The debris is evacuated from the window in the hypotympanum. The labyrinthectomy is further carried out to gain access to the cholesteatoma from the mastoid. Superiorly, semicircular canals are removed, and the vestibule is opened (arrow). CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; SS, sigmoid sinus.

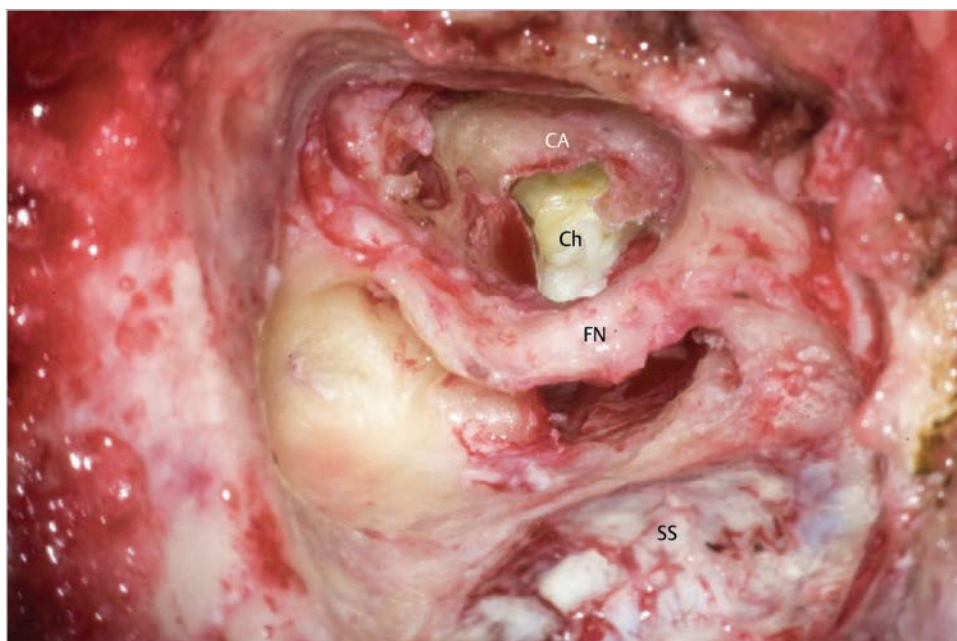


Fig. 14.439 The cholesteatoma is dissected from the posterior dura from the opening under the facial nerve. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; SS, sigmoid sinus.

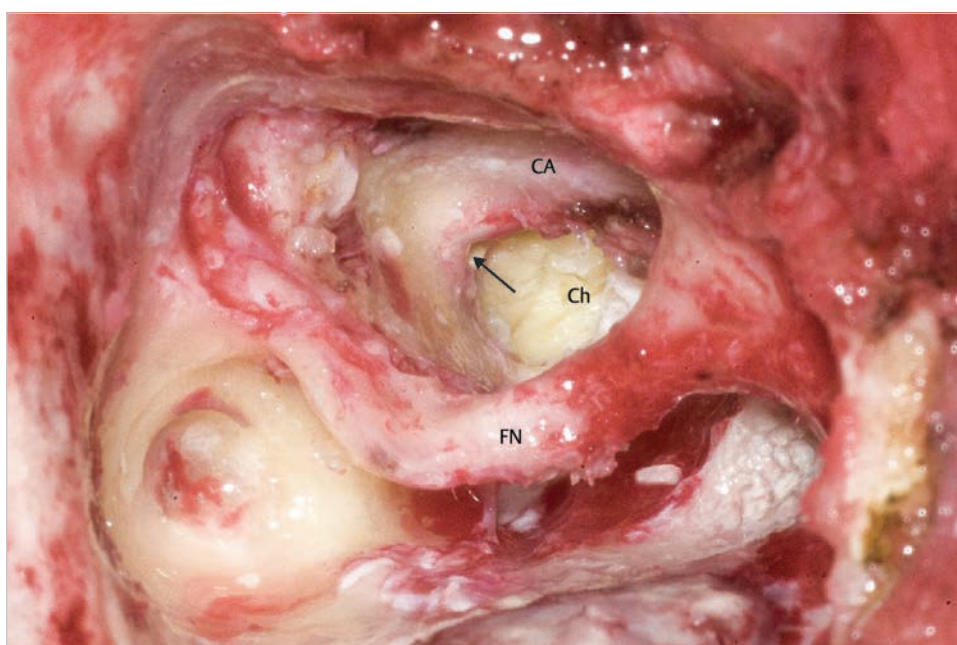


Fig. 14.440 The cochlea is further drilled. Some bone still limiting access to the petrous apex is left posteriorly to the carotid artery (arrow). CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

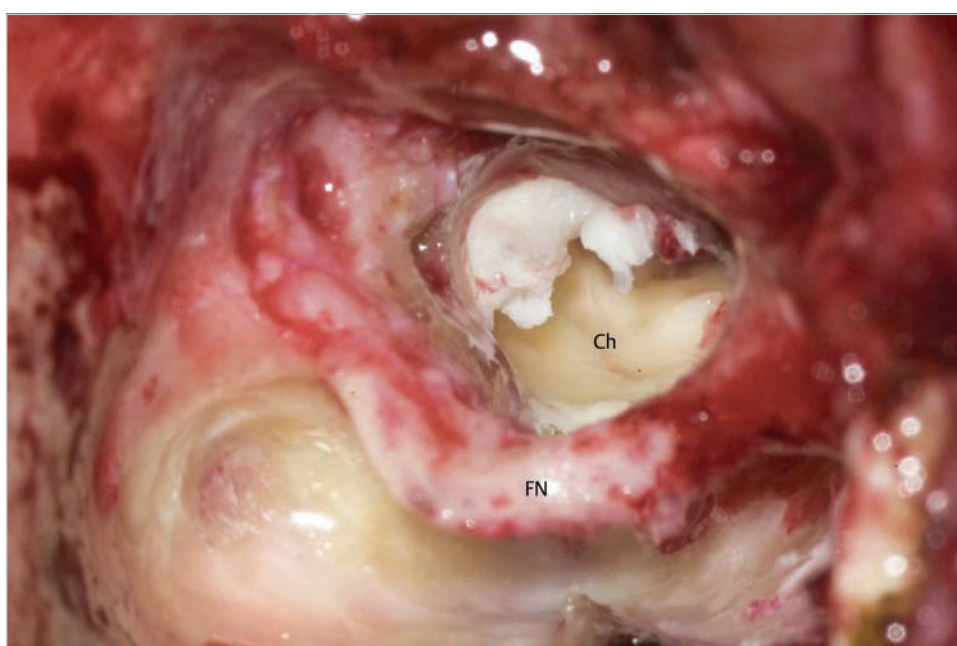


Fig. 14.441 The bone is removed to enlarge access to the petrous apex. Some matrix covered by that bone is exposed. Debris is evacuated to debulk the cholesteatoma for following dissection of the matrix from the cavity wall. Ch, cholesteatoma; FN, facial nerve.

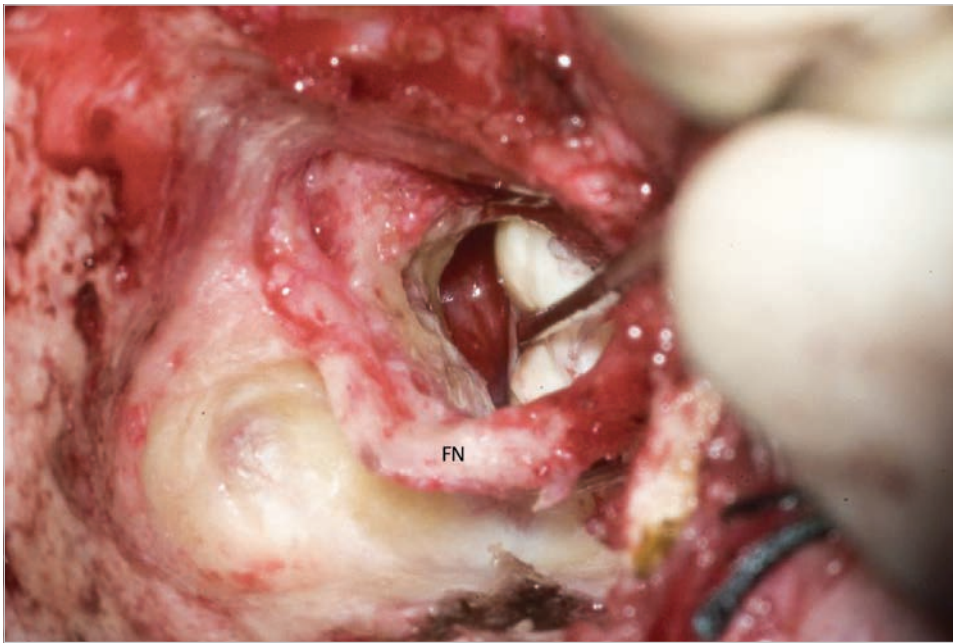


Fig. 14.442 The matrix of cholesteatoma is detached from the superior apical wall. FN, facial nerve.

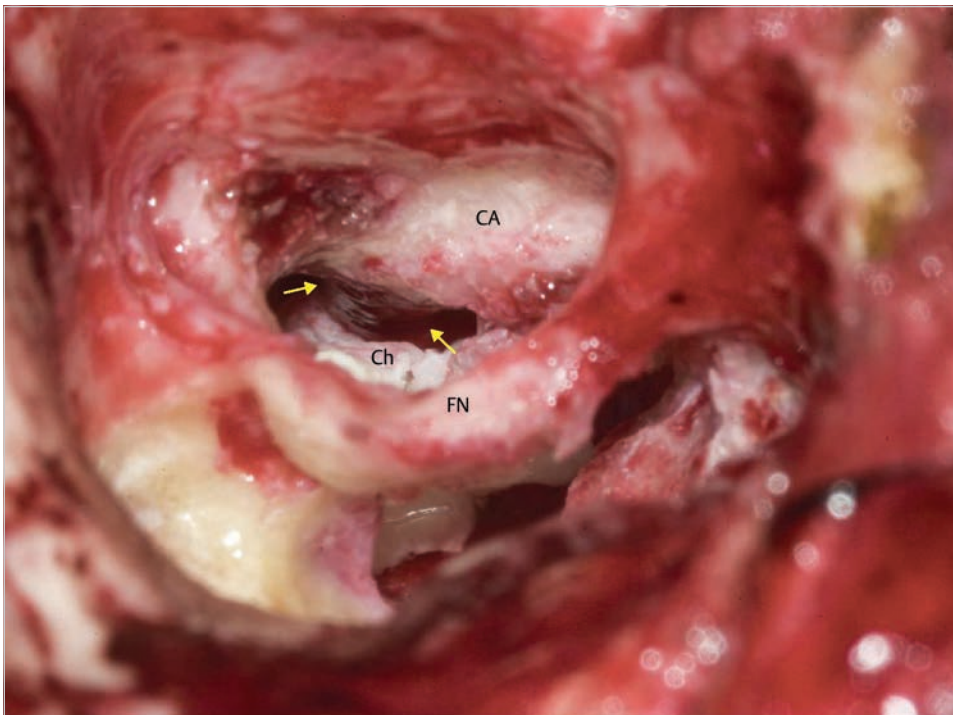


Fig. 14.443 The vertical and the horizontal portion of the internal carotid artery forming a part of the anterior wall is seen (*arrows*). CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

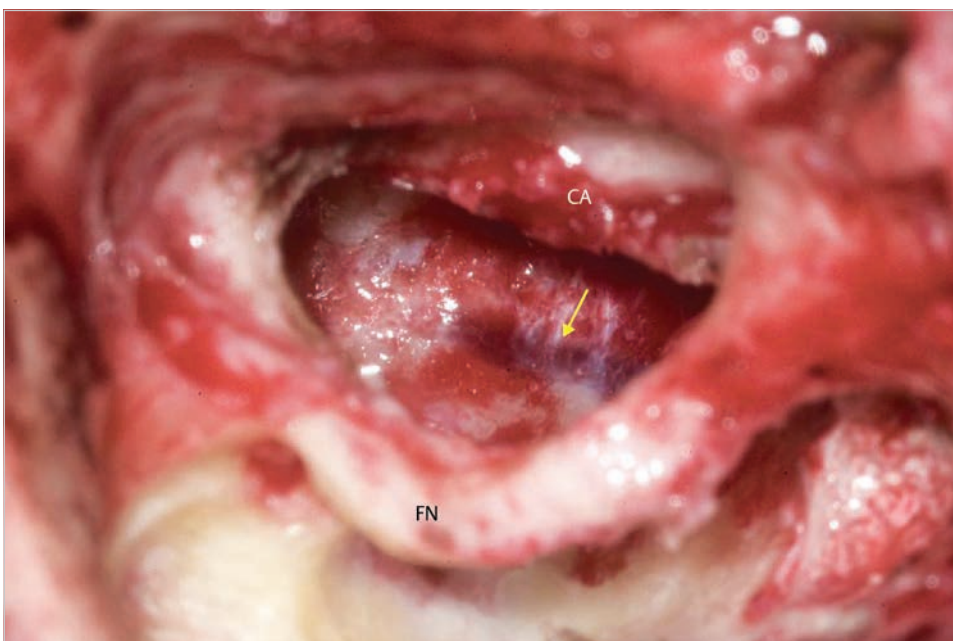


Fig. 14.444 The blue line (*arrow*) corresponds to the inferior petrosal sinus running in the junction between the petrous bone and the clivus. CA, carotid artery; FN, facial nerve.

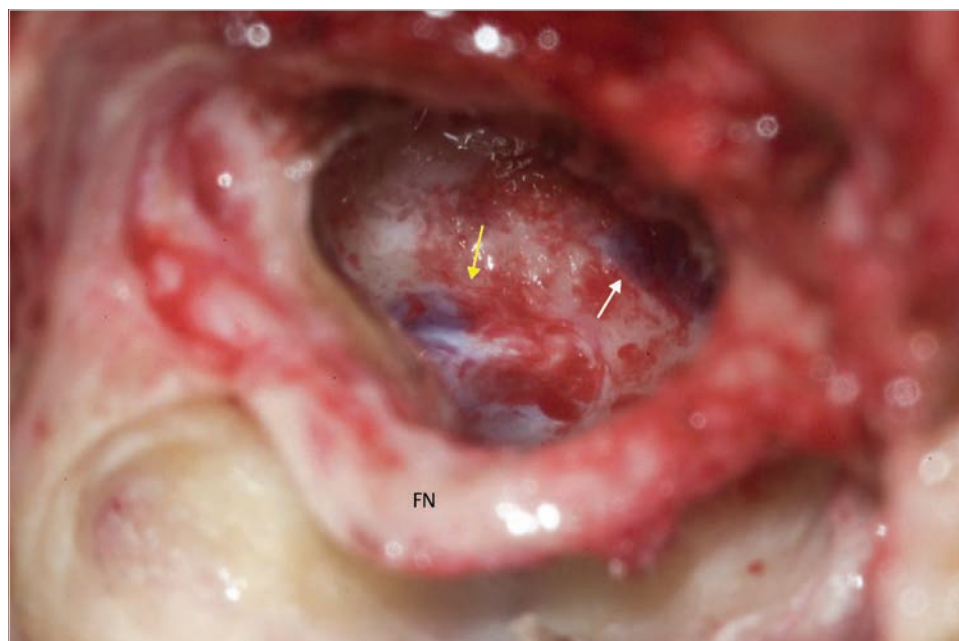


Fig. 14.445 The bluish area (*yellow arrow*) corresponds to thin dura of the internal auditory canal. Inferomedially, another triangular bluish area (*white arrow*) corresponds to the pars nervosa of the jugular foramen. FN, facial nerve.

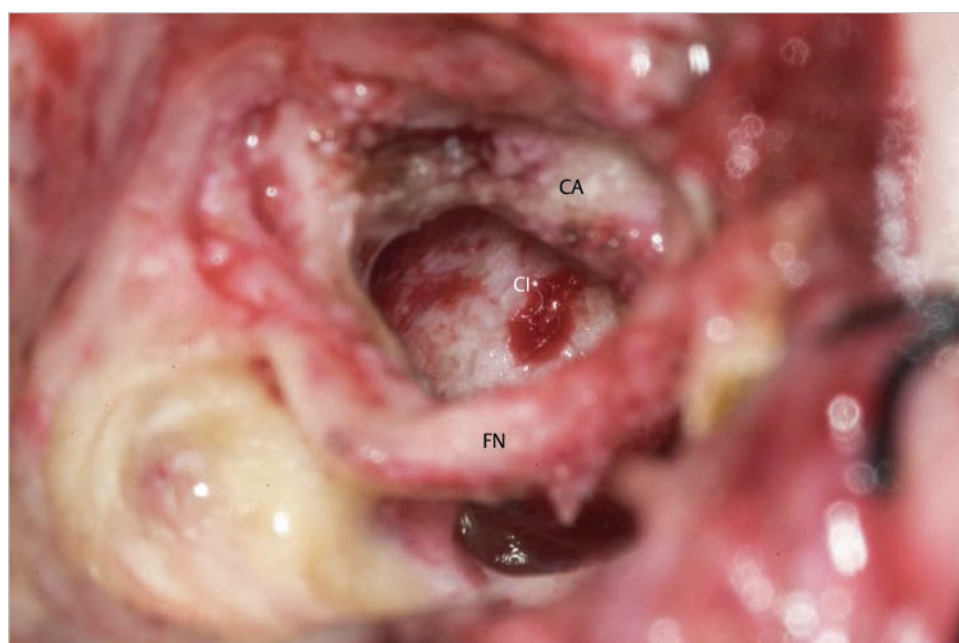


Fig. 14.446 The area of the clivus is seen. CA, carotid artery; Cl, clivus; FN, facial nerve.



Fig. 14.447 The carotid artery is gently pushed anteriorly to verify absence of cholesteatoma in the petrous apex. CA, carotid artery; FN, facial nerve.

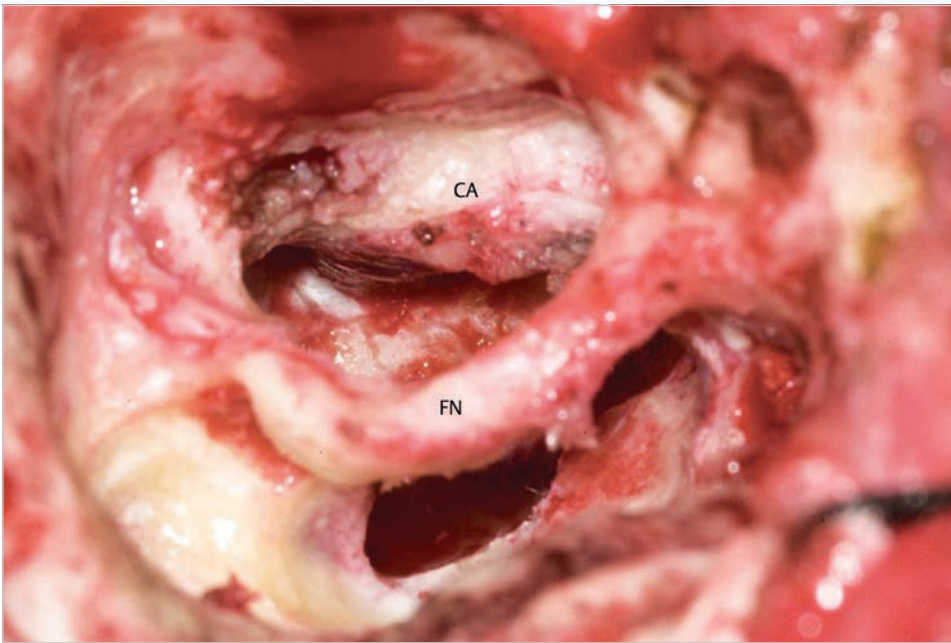


Fig. 14.448 The cholesteatoma is completely removed from the petrous apex. CA, carotid artery; FN, facial nerve.

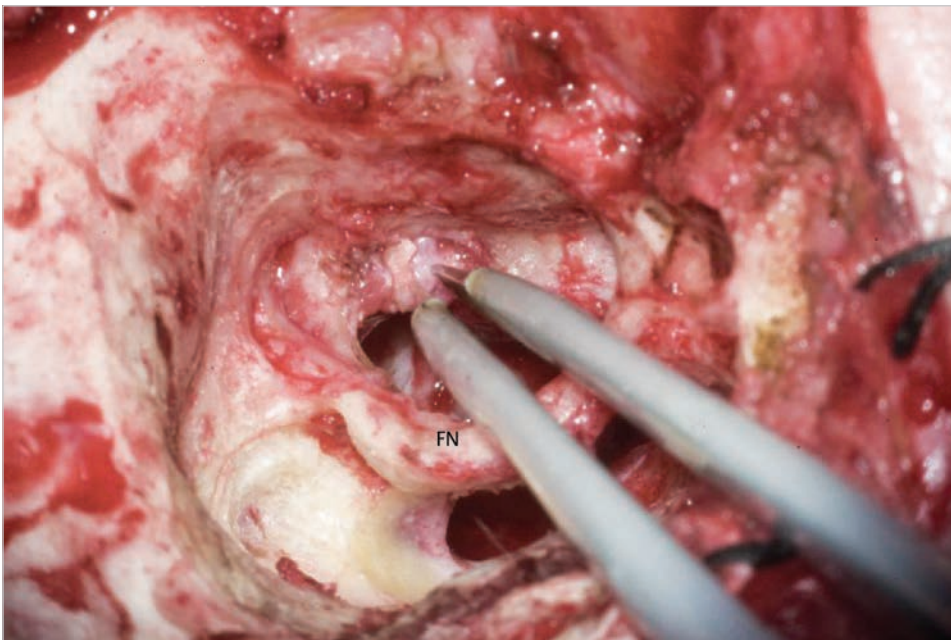


Fig. 14.449 The eustachian tube is closed with periosteum. FN, facial nerve.

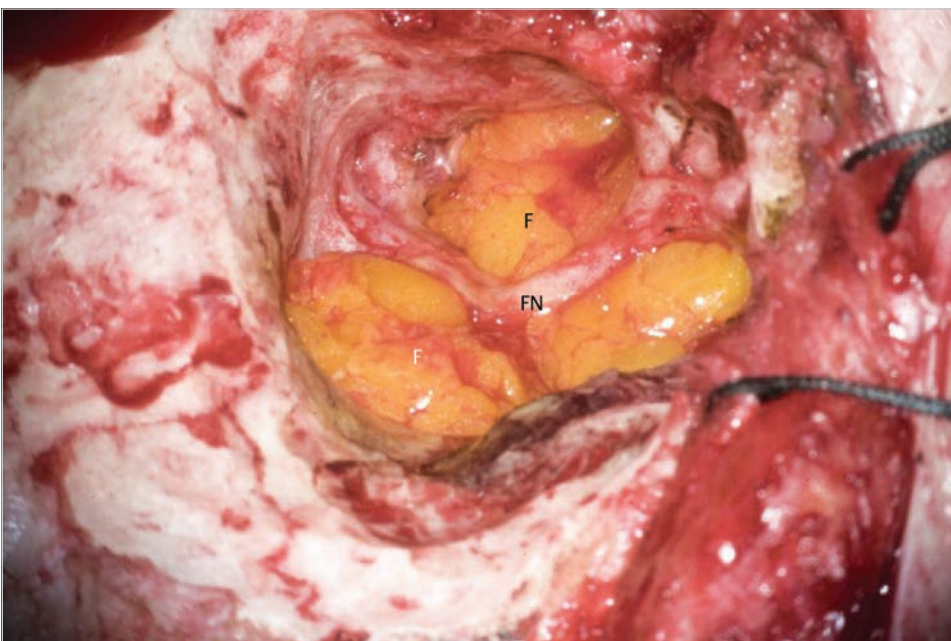


Fig. 14.450 The eustachian tube is closed with periosteum and the cavity is obliterated with abdominal fat. F, abdominal fat; FN, facial nerve.

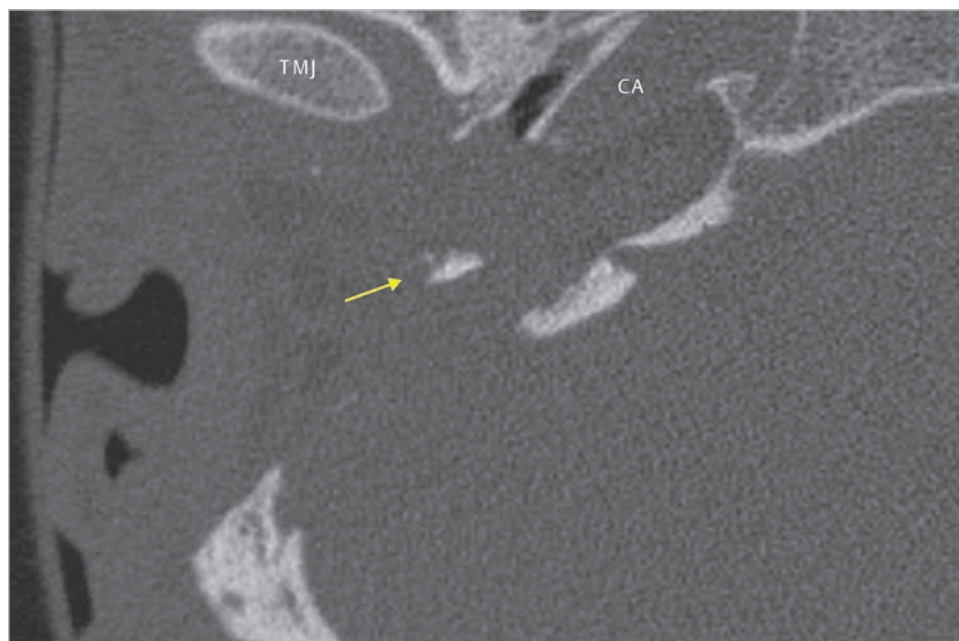


Fig. 14.451 The posterior face of the carotid artery is exposed, and the mastoid segment of the facial nerve is demonstrated as a soft tissue on the bony bridge left medially to the nerve (*arrow*). CA, carotid artery; TMJ, temporomandibular joint.

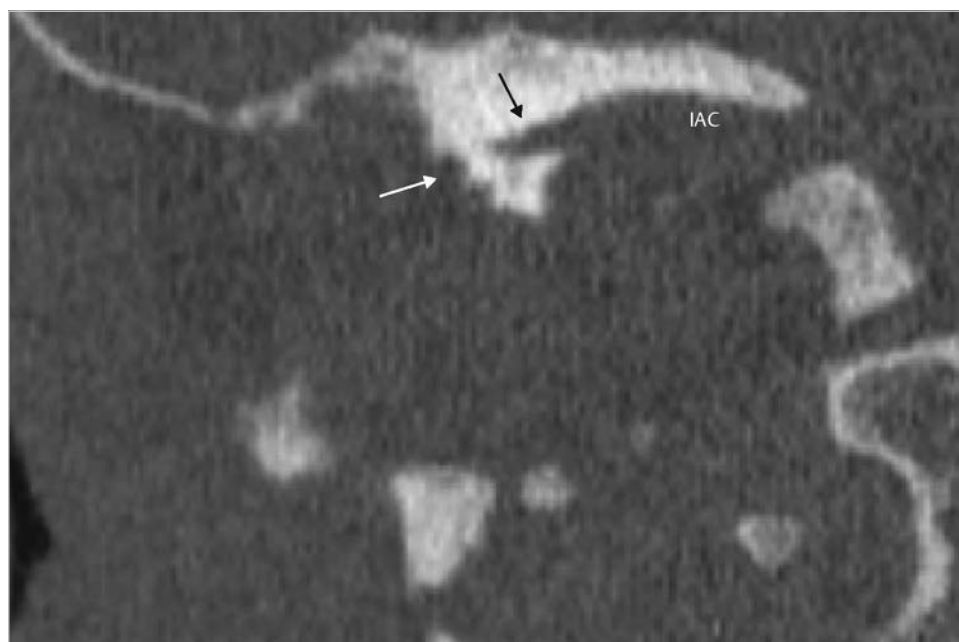


Fig. 14.452 The coronal section demonstrates large approach to the petrous apex established inferiorly to the internal auditory canal. The labyrinthine segment (*black arrow*) and the tympanic segment (*white arrow*) can be identified. IAC, internal auditory canal.

Case 14.19 (Right Ear)

See ►Fig. 14.453, ►Fig. 14.454, ►Fig. 14.455, ►Fig. 14.456, ►Fig. 14.457, ►Fig. 14.458, ►Fig. 14.459, ►Fig. 14.460, ►Fig. 14.461, ►Fig. 14.462, ►Fig. 14.463, ►Fig. 14.464, ►Fig. 14.465, ►Fig. 14.466, ►Fig. 14.467, ►Fig. 14.468, ►Fig. 14.469, ►Fig. 14.470, ►Fig. 14.471, ►Fig. 14.472, ►Fig. 14.473, ►Fig. 14.474, ►Fig. 14.475, ►Fig. 14.476, ►Fig. 14.477, ►Fig. 14.478, ►Fig. 14.479, ►Fig. 14.480, ►Fig. 14.481, ►Fig. 14.482, ►Fig. 14.483.

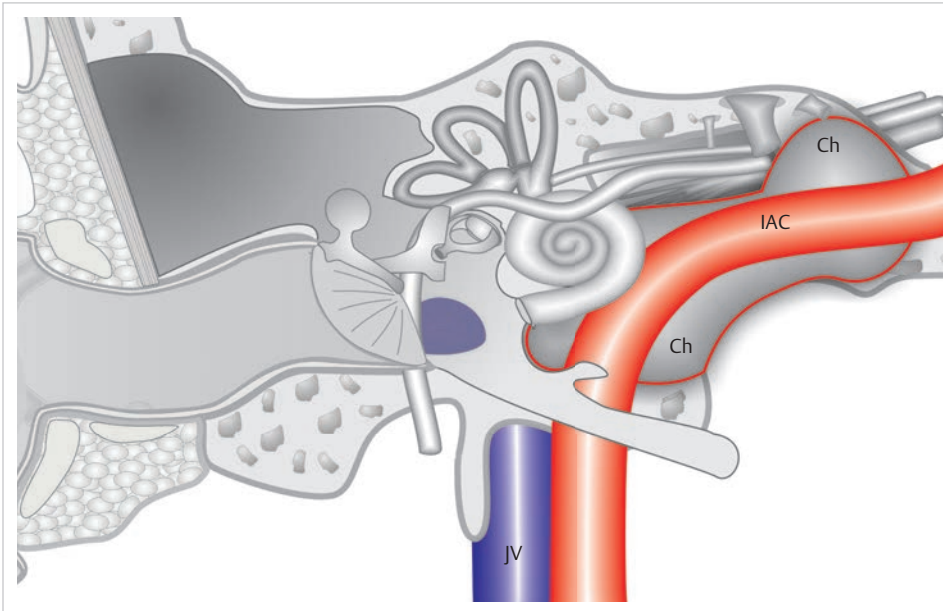


Fig. 14.453 A case of apical petrous bone cholesteatoma in a formerly operated ear treated with modified transcochlear approach combined with infratemporal fossa approach type B with facial nerve reconstruction. Ch, cholesteatoma; IAC, internal carotid artery; JV, jugular vein.

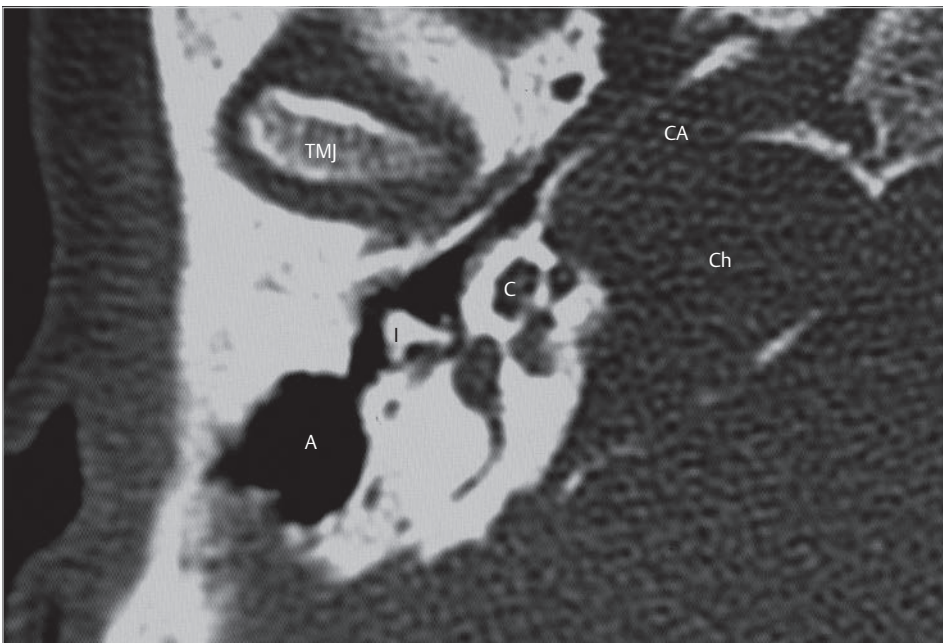


Fig. 14.454 This 32-year-old woman presented with right draining ear with profound mixed deafness after two tympanoplasties elsewhere. The axial CT shows presence of soft tissue density in the petrous apex eroding the cochlea. A molded incus was used as a columella in the former surgery. The apical region is isolated from the aerated space in the middle ear. A, antrum; C, cochlea; CA, carotid artery; Ch, cholesteatoma; I, incus columella; TMJ, temporomandibular joint.

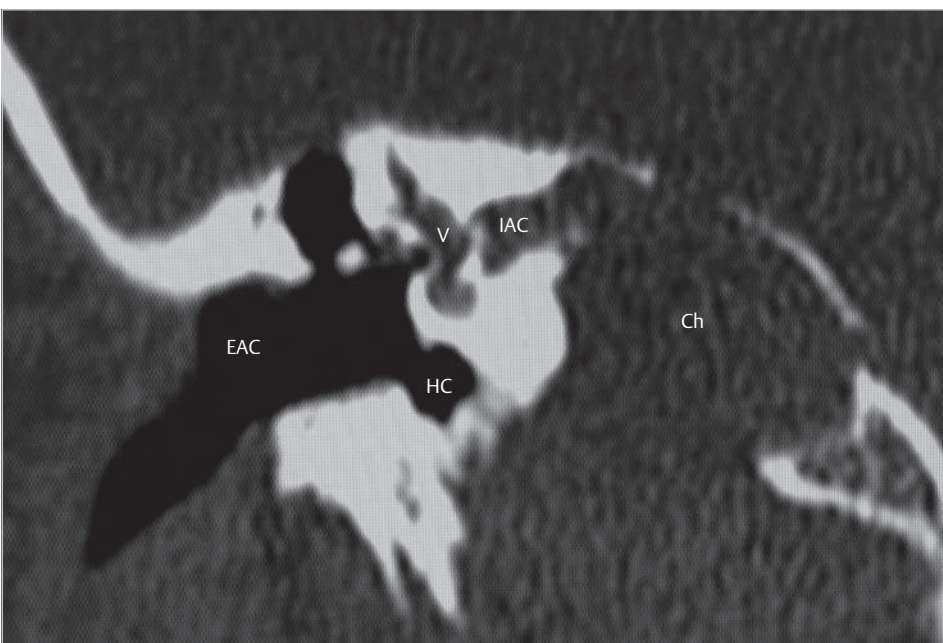


Fig. 14.455 The coronal CT shows infiltration of the hypotympanic cells with the soft tissue. The internal auditory canal is also eroded. Note that no pathology is seen in the middle ear cleft and the mastoid. Ch, cholesteatoma; EAC, external auditory canal; HC, hypotympanic cells; IAC, internal auditory canal; V, vestibule.

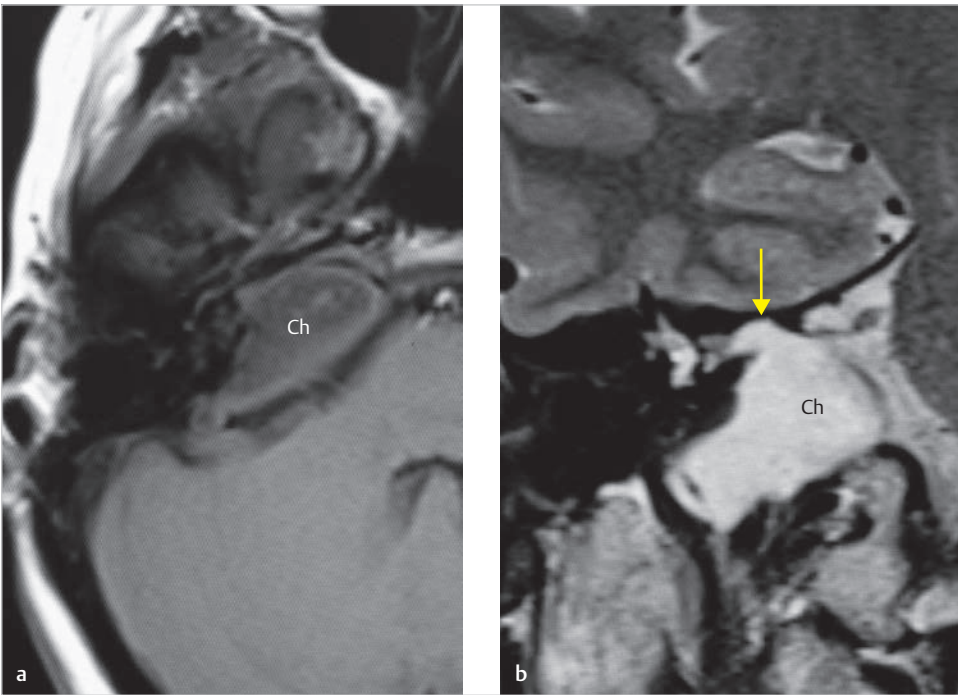


Fig. 14.456 The lesion shows low in T1-weighted axial MRI image (a), and high signal in T2-weighted coronal image (b). Invagination of the cholesteatoma into the auditory canal is shown (arrow). Ch, cholesteatoma.

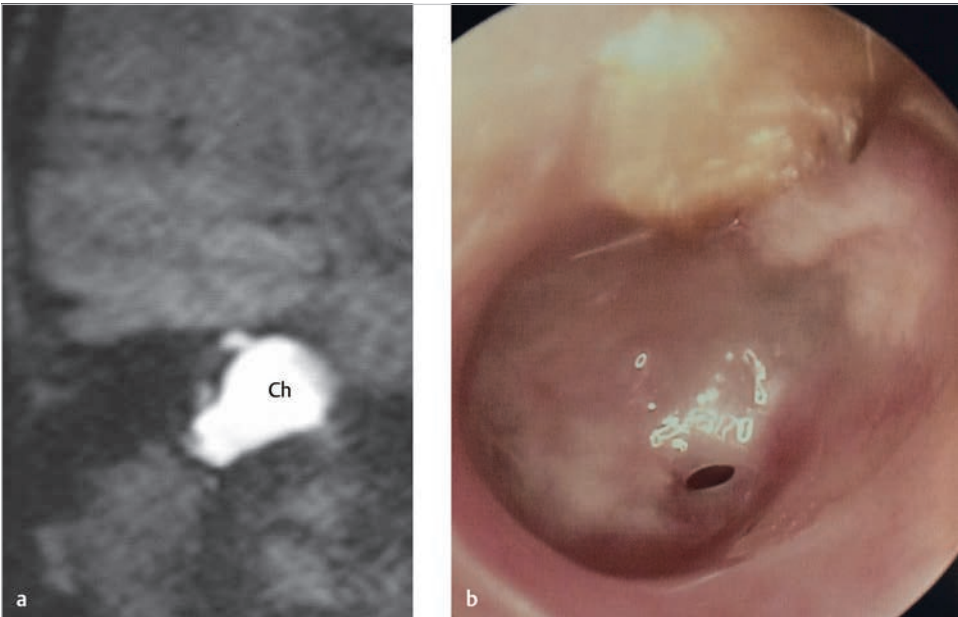


Fig. 14.457 A very high signal in a coronal section of diffusion-weighted image MRI (a) indicated presence of cholesteatoma in the petrous apex. In spite of such extensive involvement of the temporal bone, a small perforation in the inflamed tympanic membrane is the only finding obtained under otoscopic examination (b). Ch, cholesteatoma.

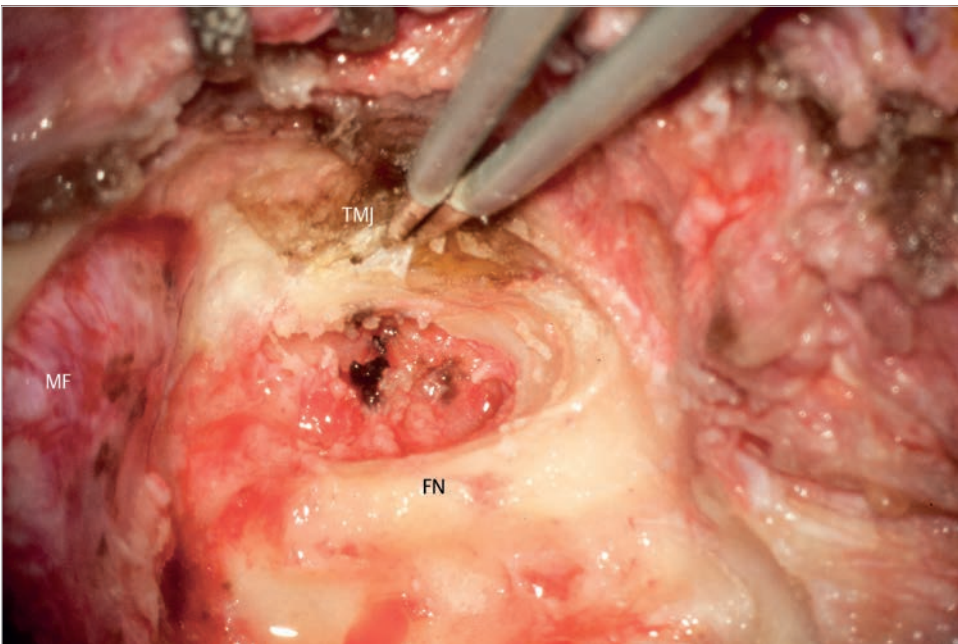


Fig. 14.458 The meatal skin and the tympanic membrane are removed, and the posterior meatal wall is drilled. The middle fossa dura is exposed to control petrous lesion. The temporomandibular joint is exposed and shrunk with bipolar coagulation to gain access to the area of the carotid artery. FN, facial nerve; MF, middle fossa dura; TMJ, temporomandibular joint.

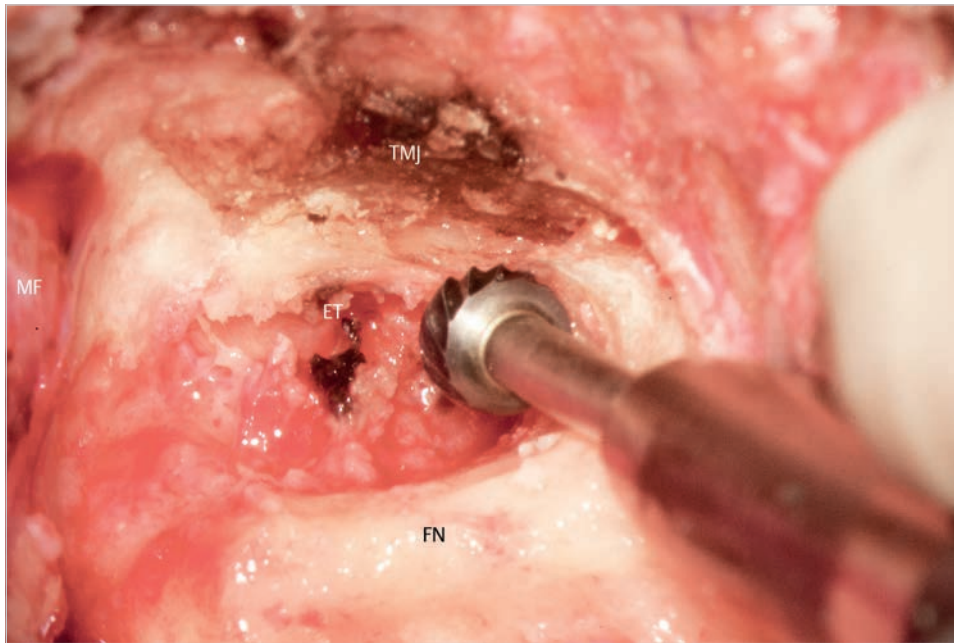


Fig. 14.459 The bony annulus is drilled to expose the hypotympanic cells that are infiltrated by cholesteatoma. ET, eustachian tube; FN, facial nerve; MF, middle fossa dura; TMJ, temporomandibular joint.

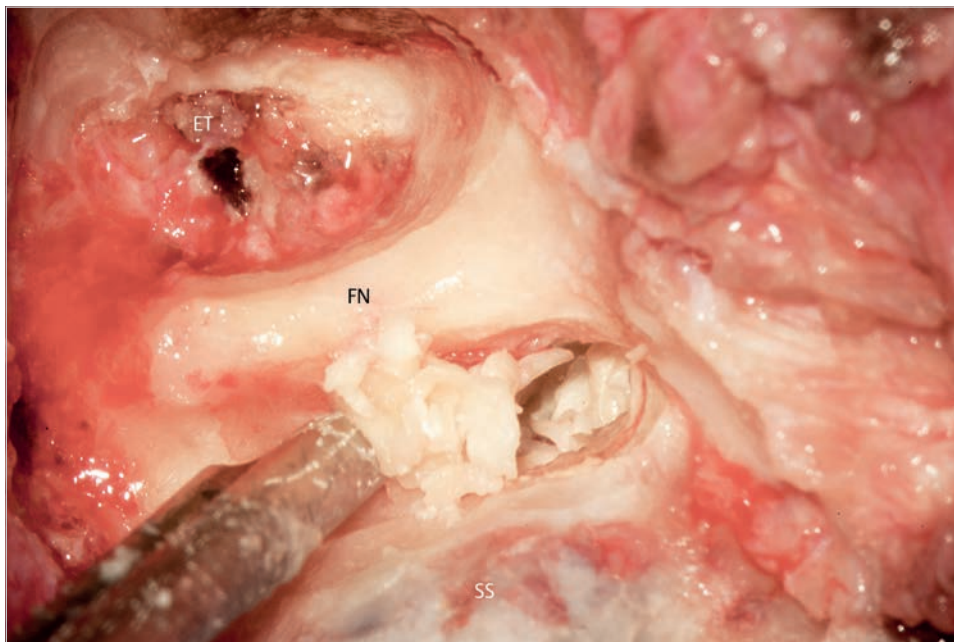


Fig. 14.460 The sigmoid sinus is exposed, and the posterior fossa dura is followed medially to reach cholesteatoma eroding the retrofacial cells. ET, eustachian tube; FN, facial nerve; SS, sigmoid sinus.

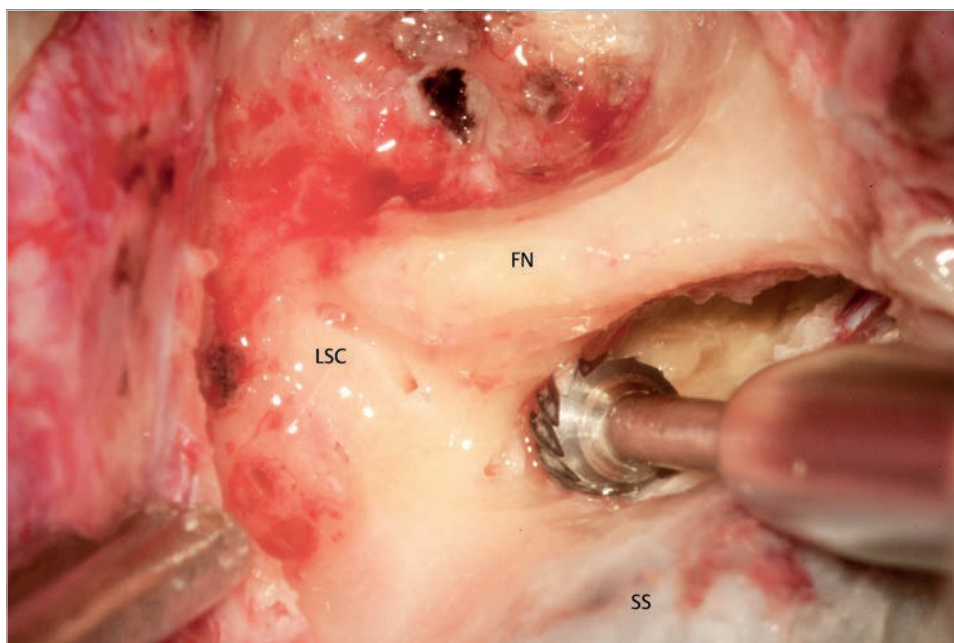


Fig. 14.461 Access to the posterosuperior part of the cholesteatoma is blocked by the labyrinth. To gain access to the area, the posterior and the lateral semicircular canals are drilled. FN, facial nerve; LSC, lateral semicircular canal; SS, sigmoid sinus.

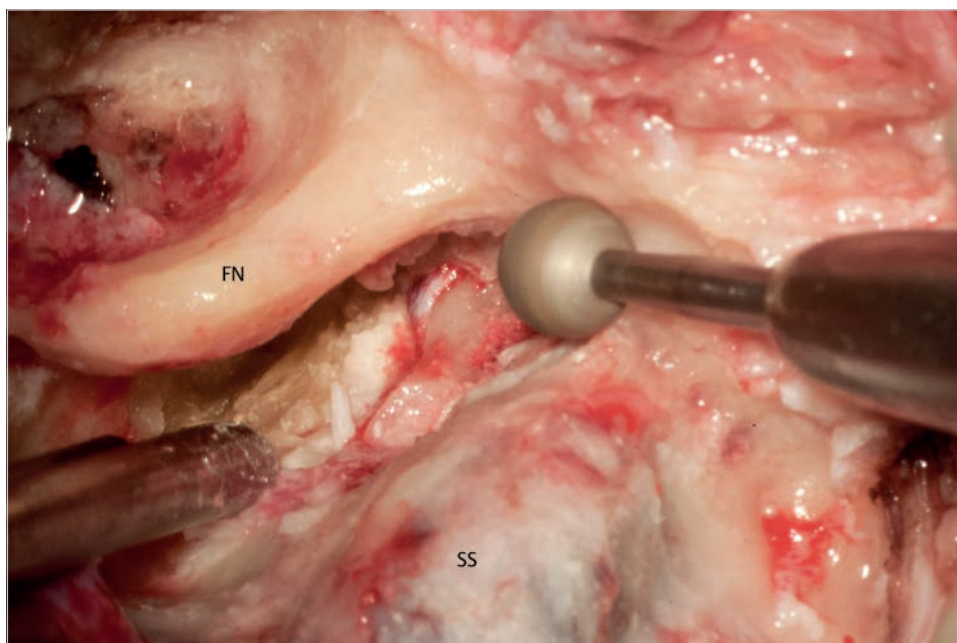


Fig. 14.462 Drilling between the sigmoid sinus and the facial nerve is advanced inferiorly with a large diamond burr to gain access to the inferior part of cholesteatoma covering the jugular bulb. FN, facial nerve; SS, sigmoid sinus.

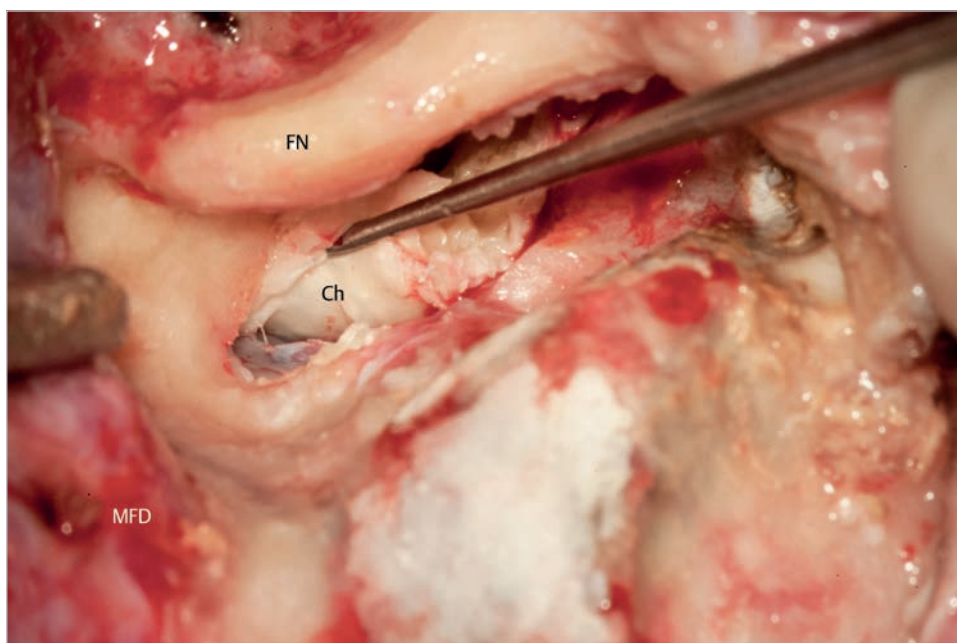


Fig. 14.463 Debulking of cholesteatoma occupying the area posteriorly to the internal auditory canal is carried out. The posterior fossa dura covered with the matrix is seen. Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura.

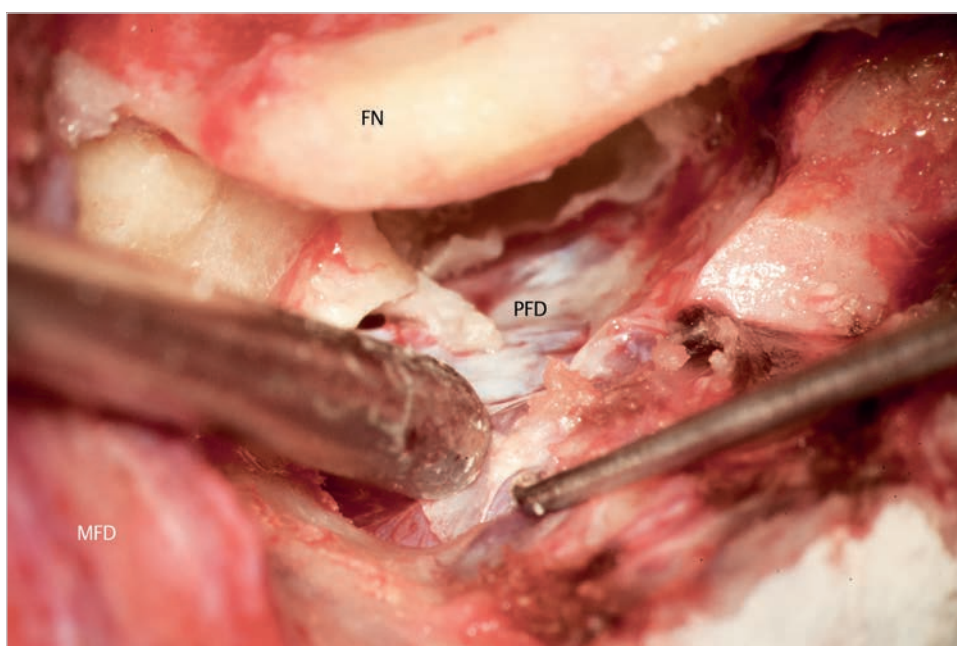


Fig. 14.464 The matrix covering the posterior fossa dura is dissected taking care not to tear it. The area where incomplete removal is suspected should be coagulated with bipolar. FN, facial nerve; MFD, middle fossa dura; PFD, posterior fossa dura.

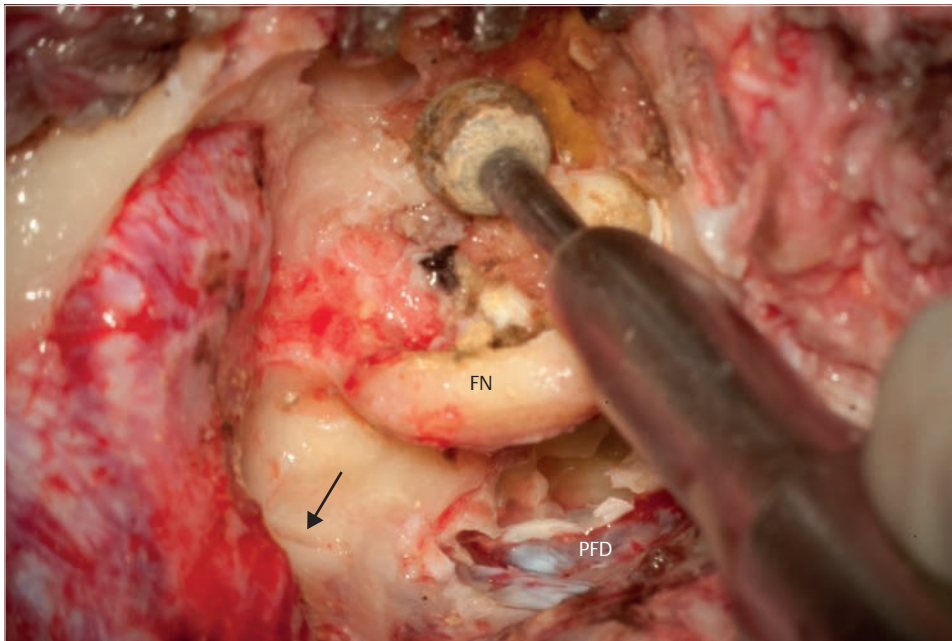


Fig. 14.465 The hypotympanic cells infiltrated by cholesteatoma is started to be drilled. The lateral and the posterior semicircular canals have already been removed. The superior semicircular canal is seen (*arrow*). FN, facial nerve; PFD, posterior fossa dura.

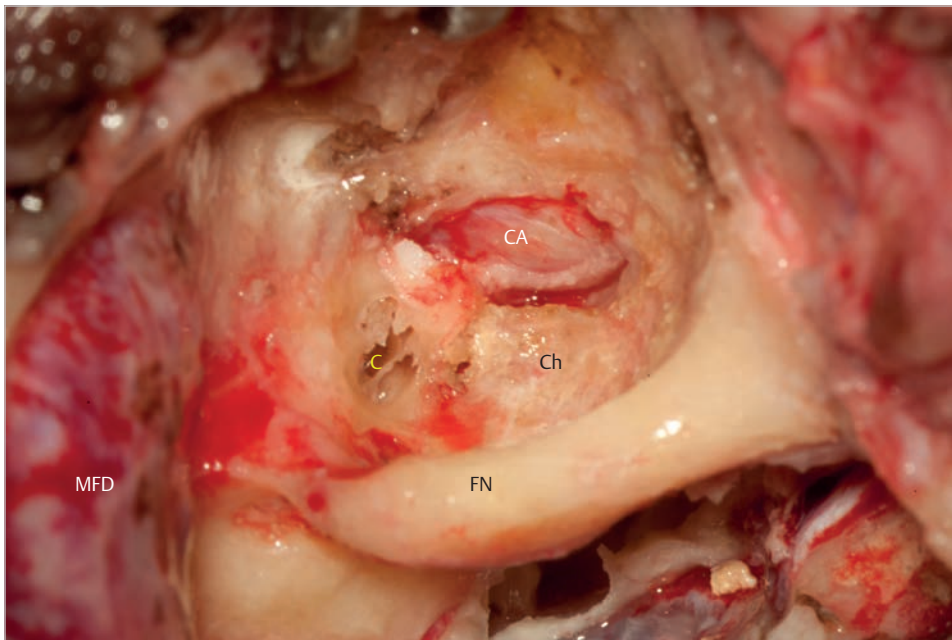


Fig. 14.466 The cochlea is drilled to enlarge the approach anterior to the facial nerve to the petrous apex. C, cochlea; CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura.

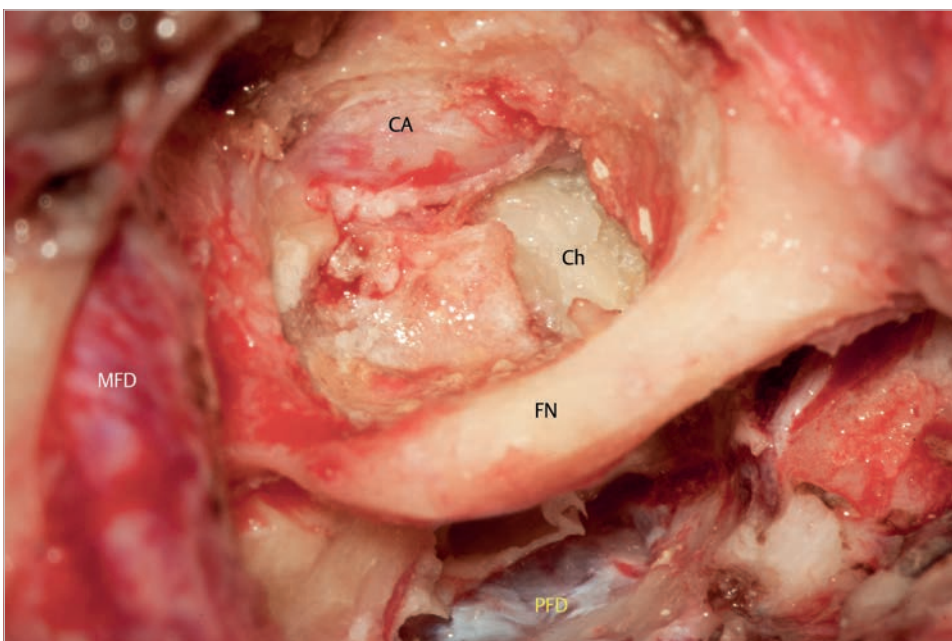


Fig. 14.467 The posterior face of the temporomandibular joint is completely exposed and shrunk with bipolar coagulation. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura; PFD, posterior fossa dura.

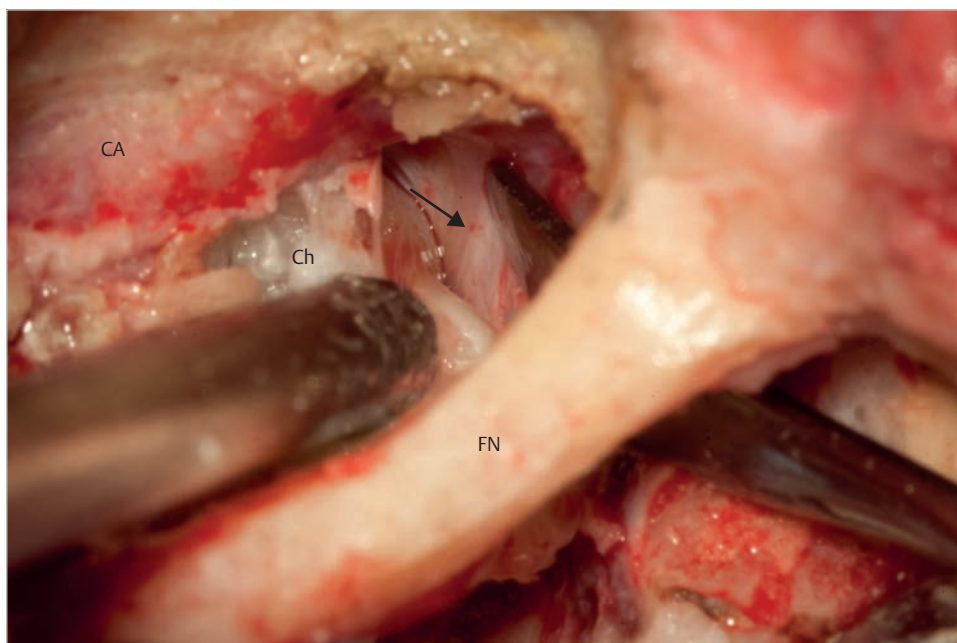


Fig. 14.468 Cholesteatoma is pushed superiorly and detached from the periosteum of the inferior face of the pyramidal bone. The whitish string running from medial to lateral is the glossopharyngeal nerve (*arrow*) that courses at the top of the pars nervosa of the jugular foramen. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

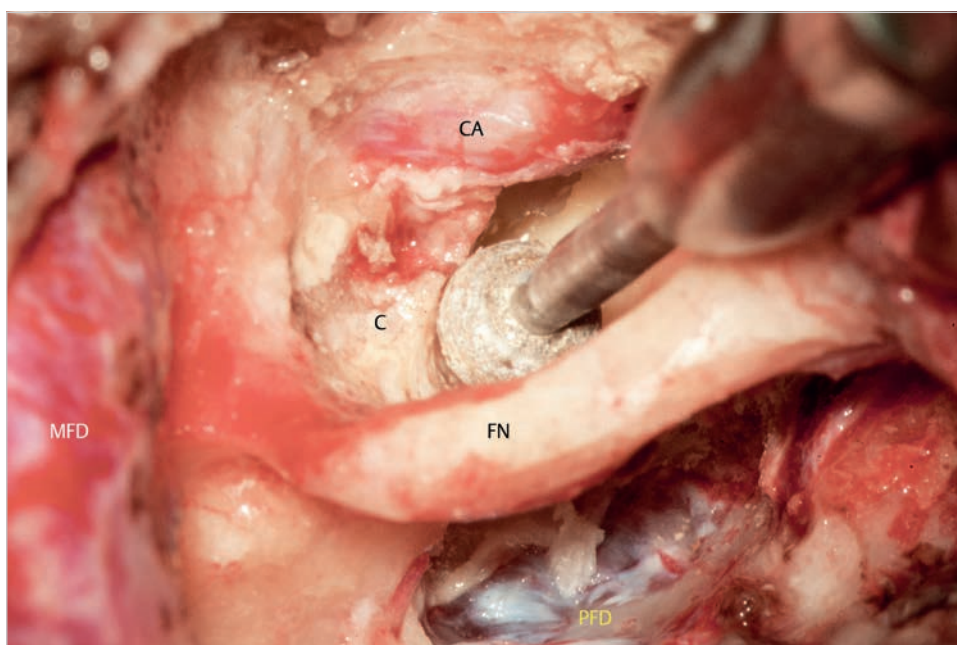


Fig. 14.469 The compact bone of the cochlea corresponding to the otic capsule is removed with a large diamond burr. Great care should be taken in this procedure, since a slip of small burs may penetrate the carotid artery, and excessive removal of the bone near the superior pole of the cochlea may cause damage to the labyrinthine segment of the facial nerve. C, cochlea; CA, carotid artery; FN, facial nerve; MFD, middle fossa dura; PFD, posterior fossa dura.

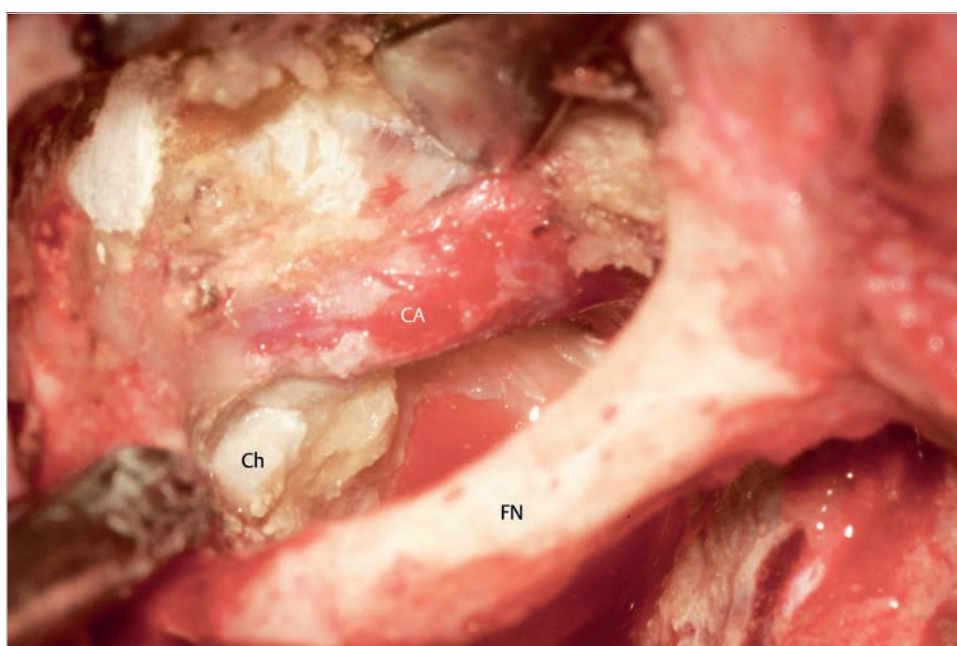


Fig. 14.470 Removal of the cochlea exposed the most anterosuperior part of the cholesteatoma posterior to the horizontal segment of the carotid artery. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

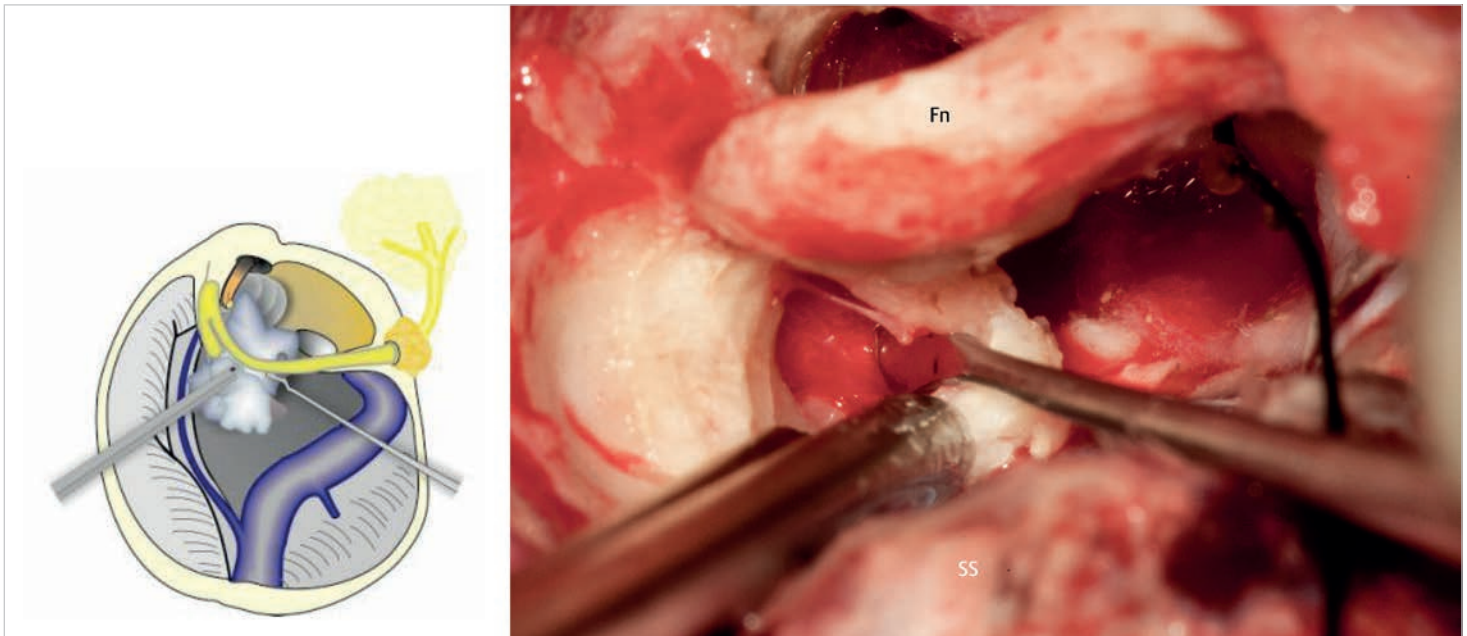


Fig. 14.471 Semicircular canals are removed, and the most posterosuperior part of cholesteatoma is dissected from the area of the internal auditory canal. FN, facial nerve; SS, sigmoid sinus.

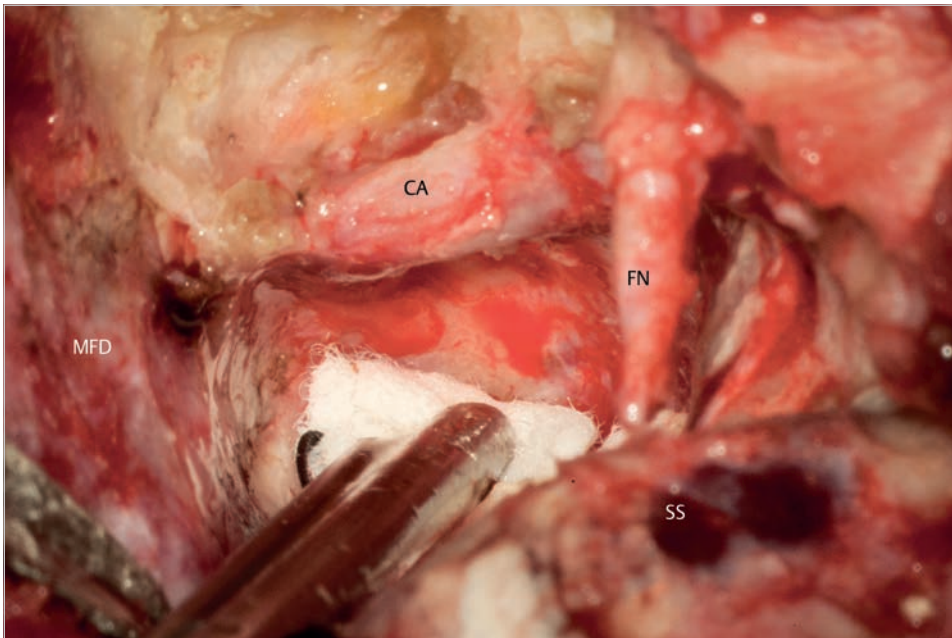


Fig. 14.472 Severe damage in the labyrinthine segment of the facial nerve necessitates sacrifice of the facial nerve. The distal stump of the nerve is seen. The procedure establishes very wide access to the petrous apex. Cottonoid is pushed with the suction irrigator to close the opening of the cerebellopontine angle. CA, carotid artery; FN, facial nerve; MFD, middle fossa dura; SS, sigmoid sinus.

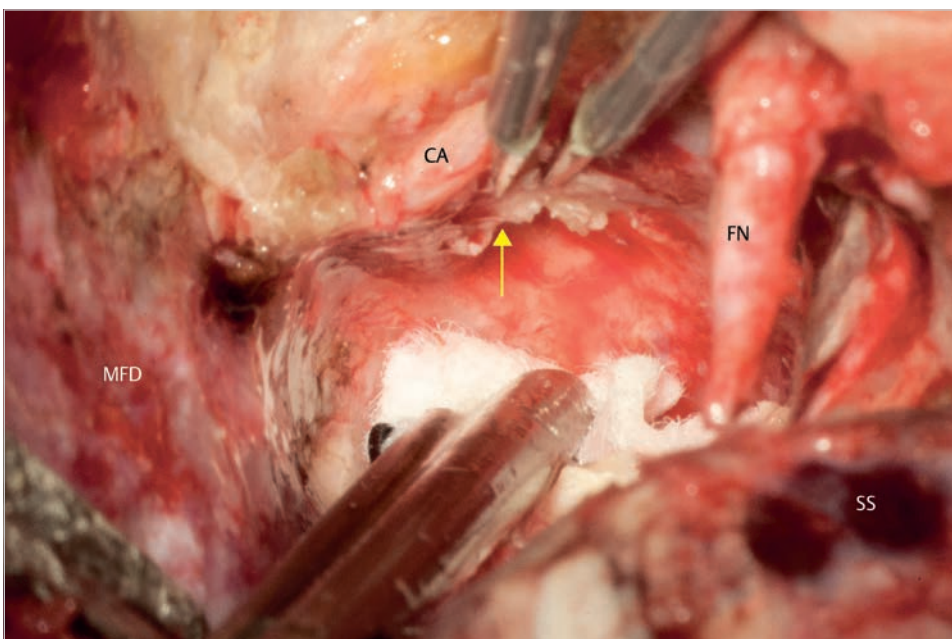


Fig. 14.473 The area of the carotid artery suspicious of complete removal of the matrix is coagulated with bipolar. Never use monopolar in this procedure. Cholesteatoma remaining medially to the vertical segment of the carotid artery is seen (arrow). CA, carotid artery; FN, facial nerve; MFD, middle fossa dura; SS, sigmoid sinus.

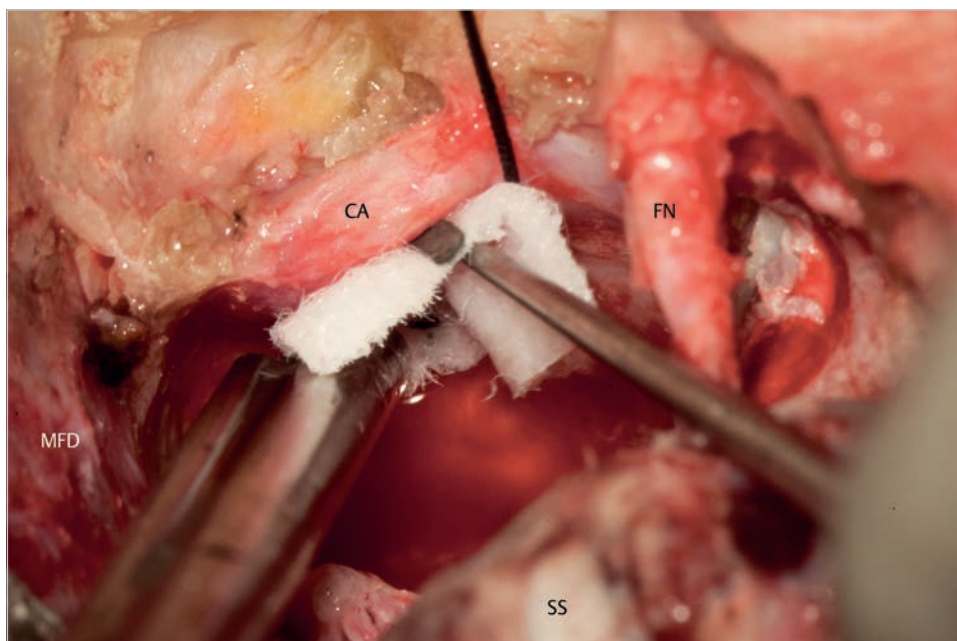


Fig. 14.474 The medial face of the vertical segment of the carotid artery suspicious of residual is scrubbed with cottonoid for complete removal. CA, carotid artery; FN, facial nerve; MFD, middle fossa dura; SS, sigmoid sinus.

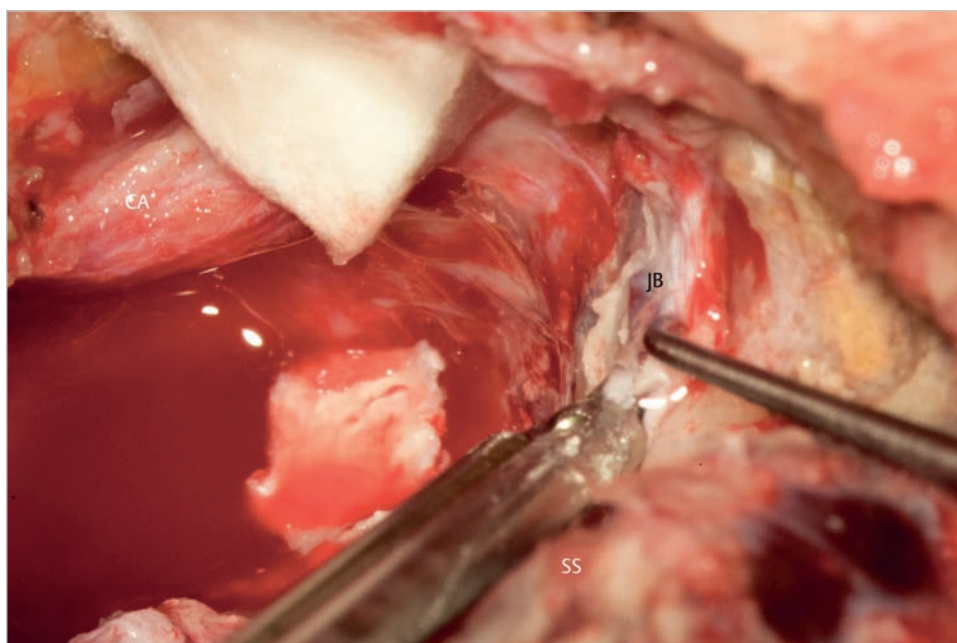


Fig. 14.475 The matrix covering the jugular bulb is dissected. Since the bulb is very fragile, great care should be taken to avoid massive bleeding. JB, jugular bulb; SS, sigmoid sinus.

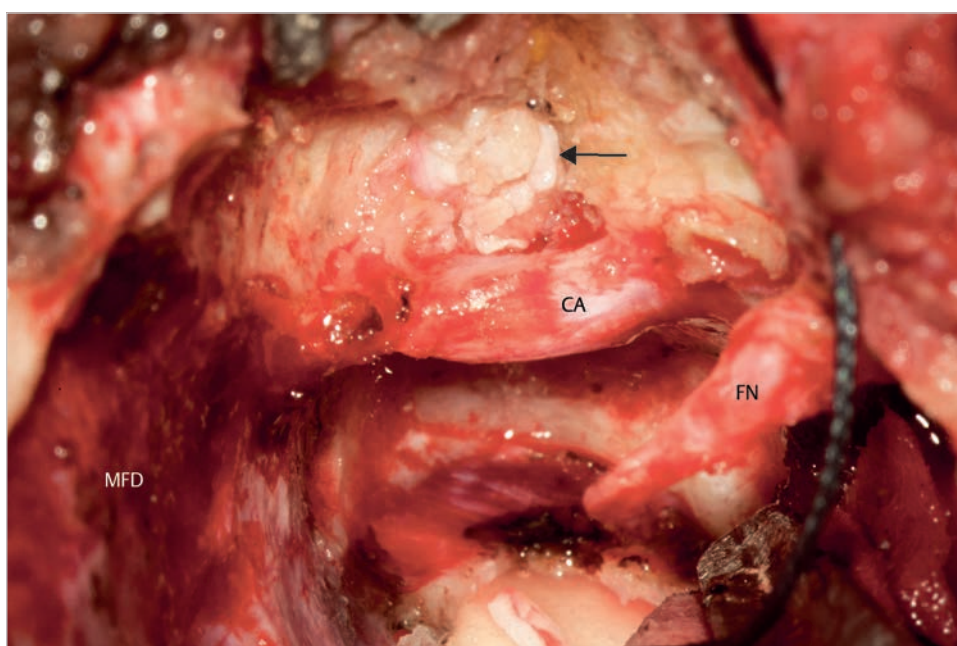


Fig. 14.476 The cholesteatoma is eradicated from the temporal bone. The eustachian tube is closed with pieces of periosteum (arrow) to avoid postoperative CSF leak. CA, carotid artery; FN, facial nerve; MFD, middle fossa dura.

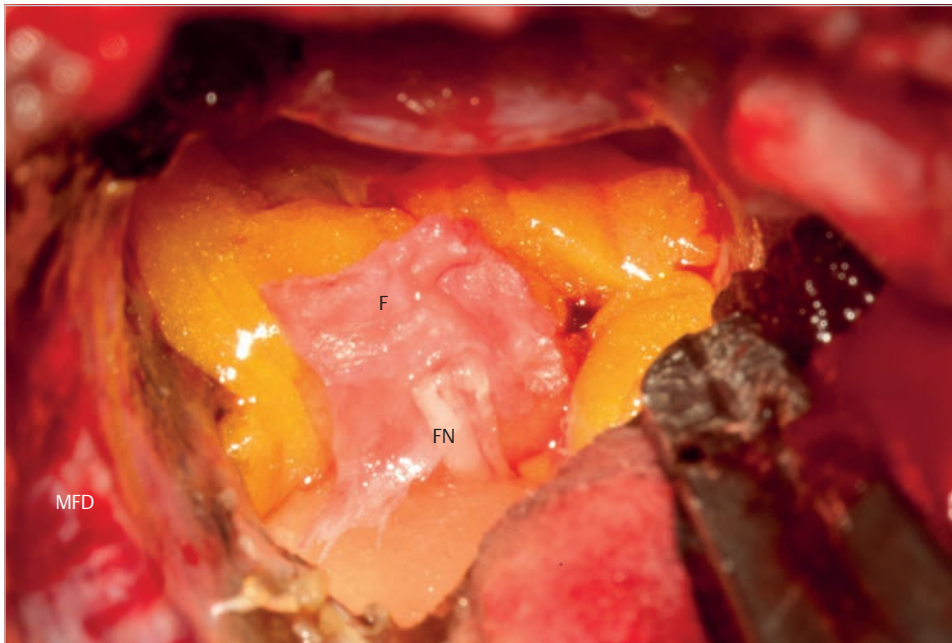


Fig. 14.477 A small piece of abdominal fat is put in the cerebellopontine (CP) angle, and a piece of temporalis fascia used to stabilize the reconstructed nerve is placed over the fat. The proximal stump of the facial nerve should be prepared with a sharp scissors. F, fascia; FN, facial nerve; MFD, middle fossa dura.

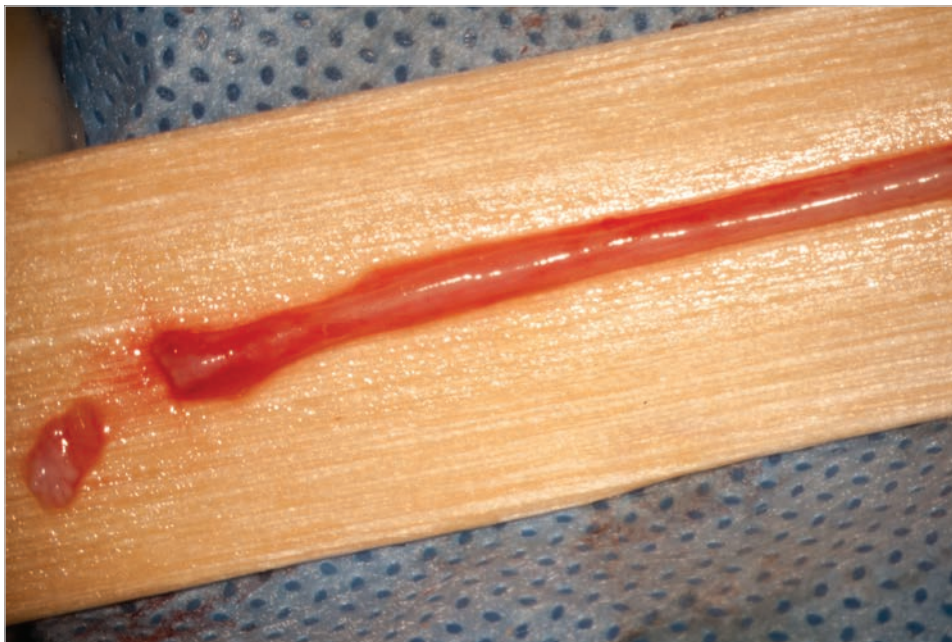


Fig. 14.478 A nerve graft is harvested from the sural nerve and placed on a tongue depressor. Both endings of the nerve are cut with a sharp knife to obtain a clear aspect.



Fig. 14.479 One end of the nerve graft is approximated to the proximal end of the facial nerve. The graft is approximated to the proximal end of the nerve. F, fascia; FN, facial nerve; G, graft.

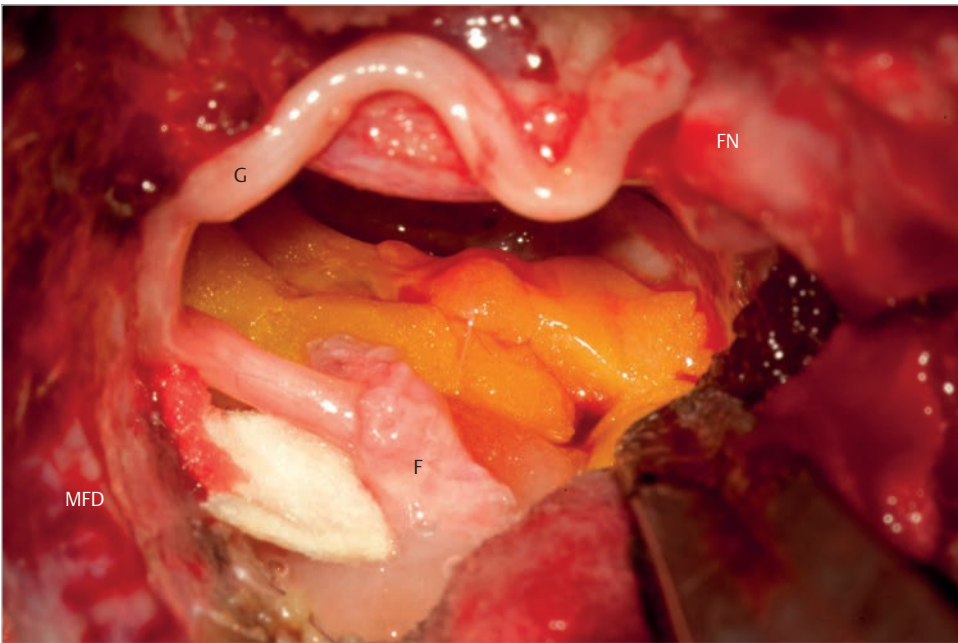


Fig. 14.480 The proximal anastomosis is wrapped with the fascia and fixed with fibrin glue. F, fascia; FN, facial nerve; G, graft; MFD, middle fossa dura.

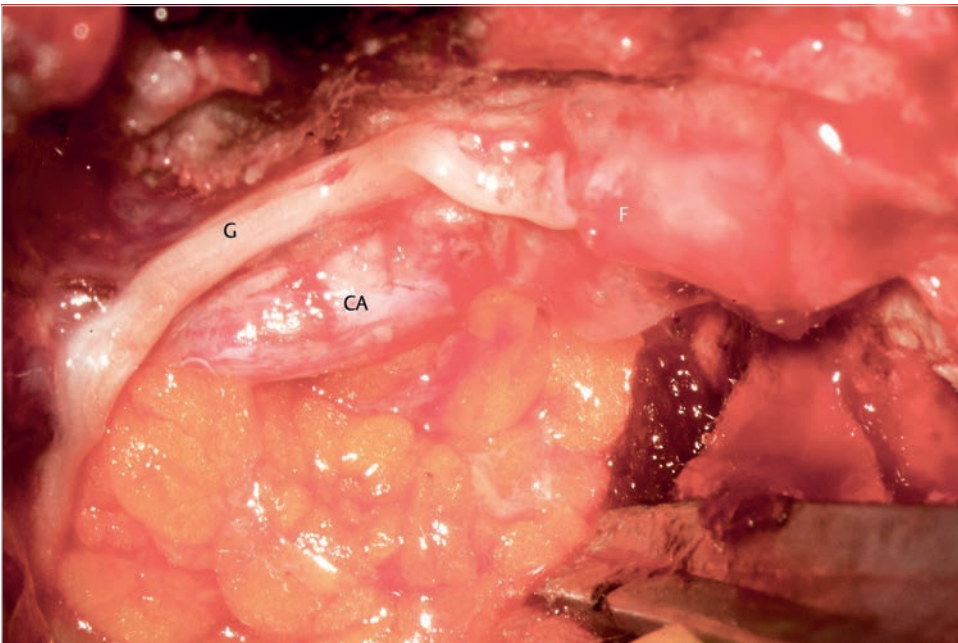


Fig. 14.481 The distal end of the sural nerve graft is approximated to the distal stump of the facial nerve, and the site of anastomosis is covered with fascia. The cavity is further packed with abdominal fat. CA, carotid artery; G, graft.

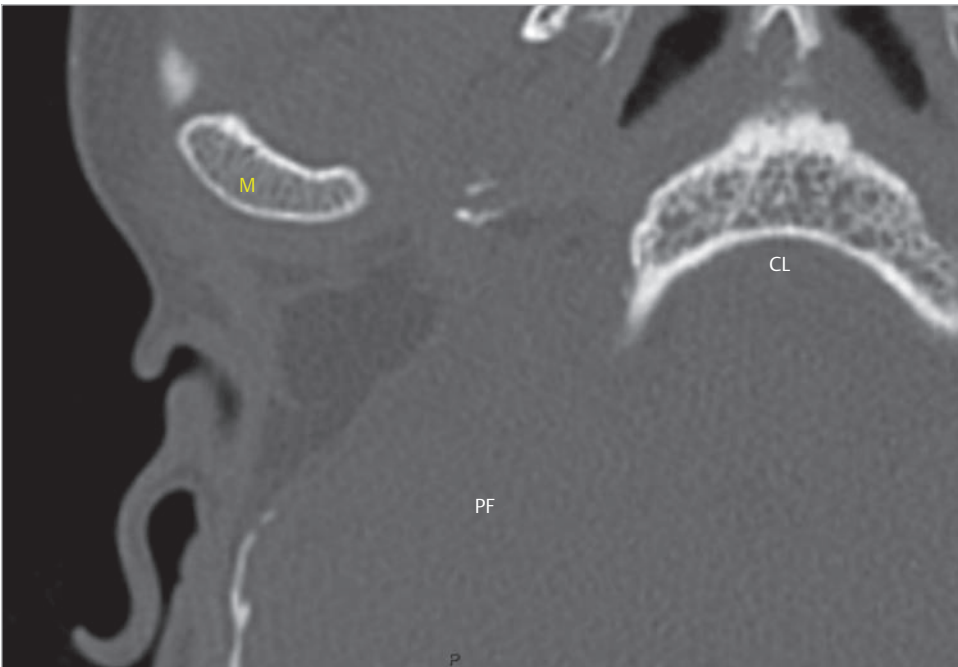


Fig. 14.482 Postoperative CT demonstrates extensive removal of petrous bone. CL, clivus; M, mandible; PF, posterior fossa.

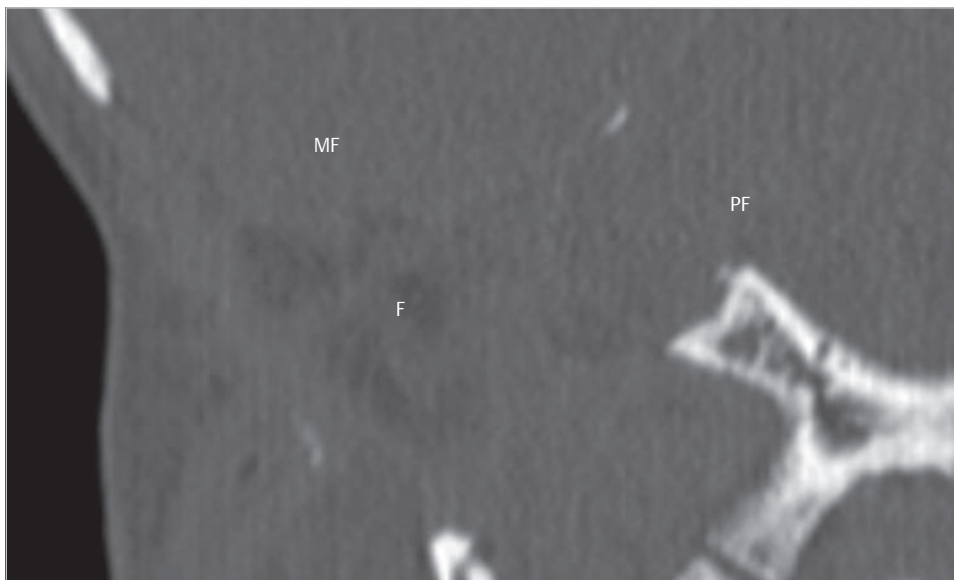


Fig. 14.483 Coronal section of CT scan is shown. Note extensive uncovering of the dura from both the middle and the posterior fossae dura. F, abdominal fat; MF, middle fossa; PF, posterior fossa.

Case 14.20 (Left Ear)

See ▶ Fig. 14.484, ▶ Fig. 14.485, ▶ Fig. 14.486, ▶ Fig. 14.487, ▶ Fig. 14.488, ▶ Fig. 14.489, ▶ Fig. 14.490, ▶ Fig. 14.491,

▶ Fig. 14.492, ▶ Fig. 14.493, ▶ Fig. 14.494, ▶ Fig. 14.495, ▶ Fig. 14.496, ▶ Fig. 14.497, ▶ Fig. 14.498, ▶ Fig. 14.499, ▶ Fig. 14.500, ▶ Fig. 14.501, ▶ Fig. 14.502, ▶ Fig. 14.503.

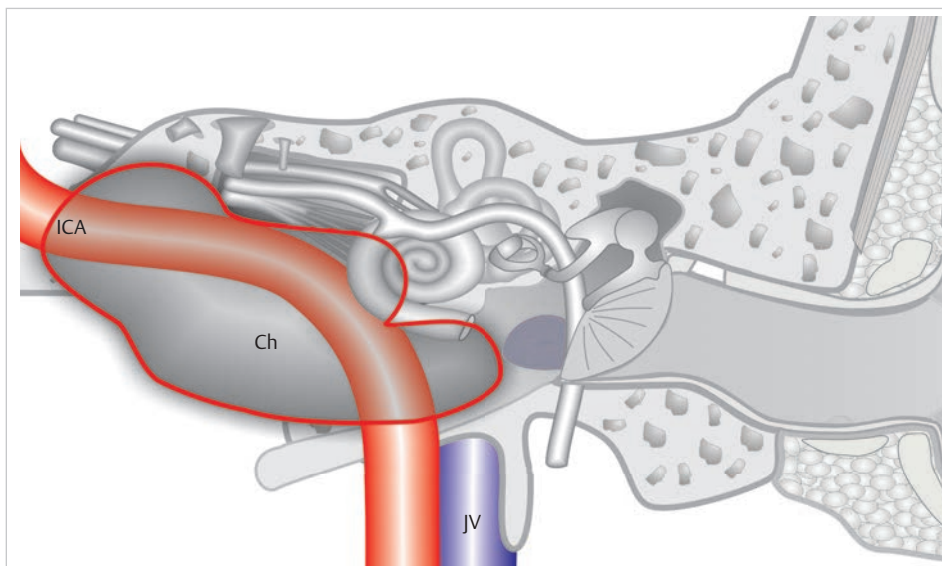


Fig. 14.484 A case of apical petrous bone cholesteatoma with clival extension treated with infratemporal fossa approach type B together with modified transcochlear approach. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

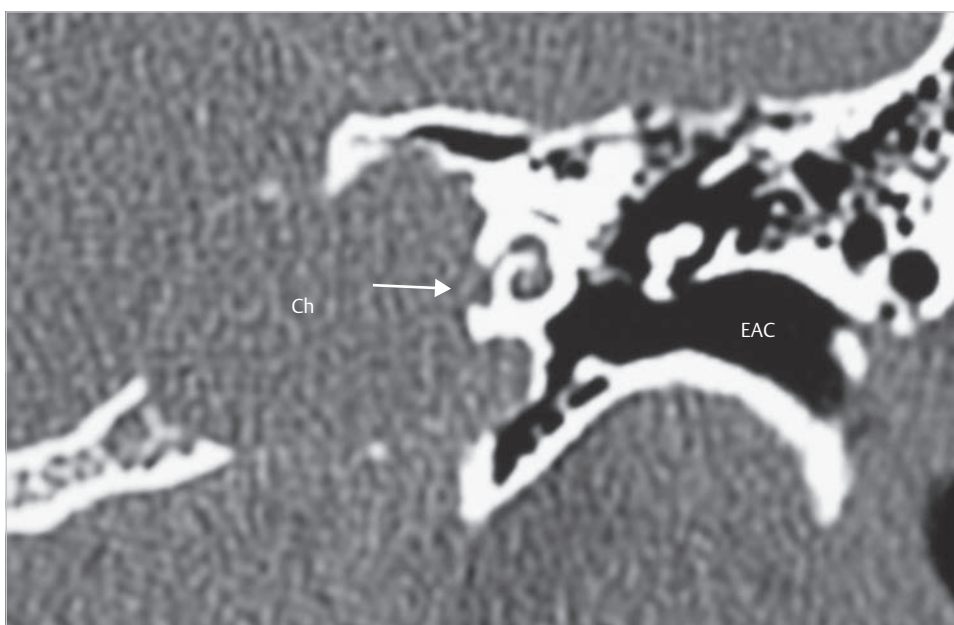


Fig. 14.485 The coronal CT shows presence of a very large petrous apex lesion eroding cochlea (arrow), completely involving the inner ear. The tympanic cavity remains intact. Ch, cholesteatoma; EAC, external auditory canal.

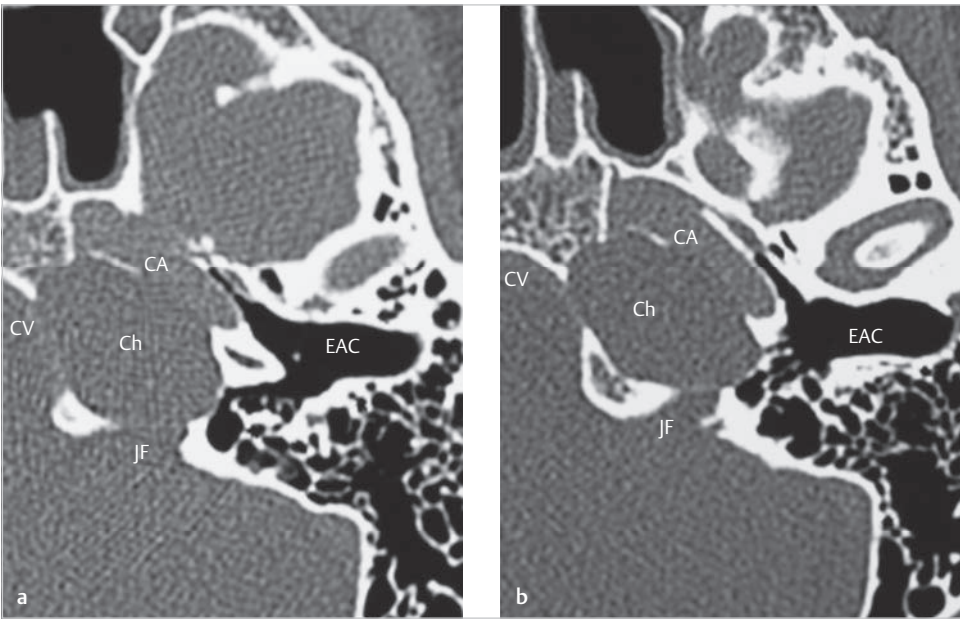


Fig. 14.486 The axial images of CT show erosion of the clivus, the jugular foramen, and the carotid canal. C, cochlea; CA, carotid artery; Ch, cholesteatoma; CV, clivus; EAC, external auditory canal; JF, jugular foramen.

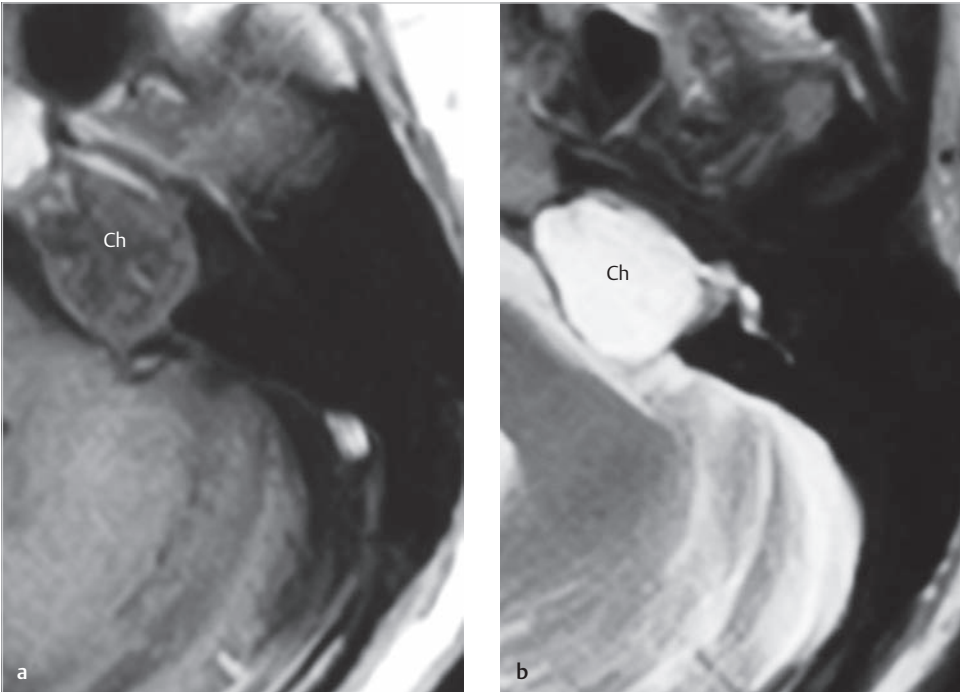


Fig. 14.487 The lesion shows low signal intensity in T1-weighted image (a), and very high intensity in T2 (b), corresponding to petrous bone cholesteatoma. Ch, cholesteatoma.

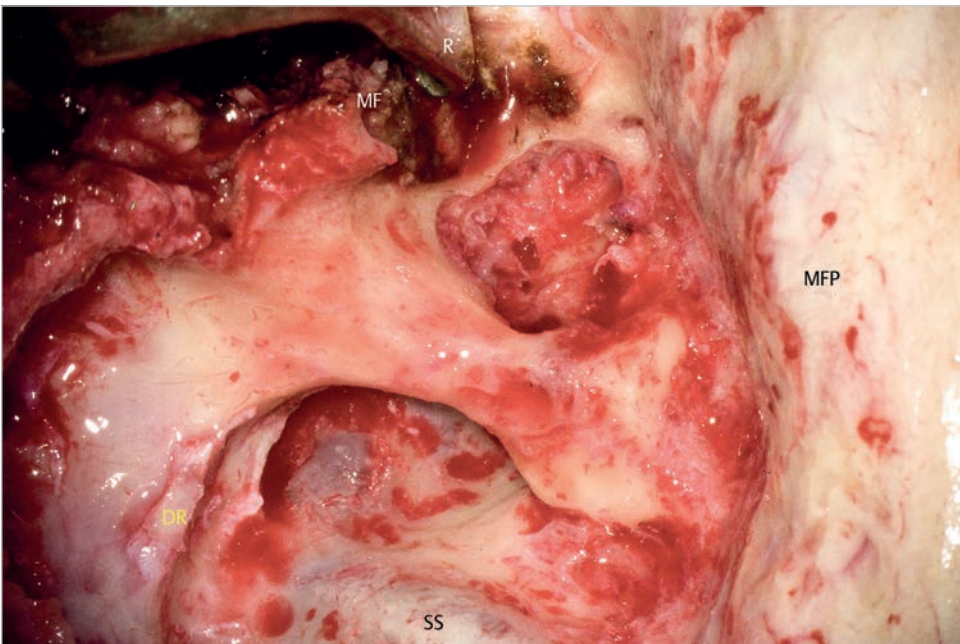


Fig. 14.488 To manage the most anteromedial part of cholesteatoma reaching the clivus, modified transotic approach that permits anterior extension of approach by moving the temporomandibular joint inferiorly is indicated. A Fisch infratemporal fossa retractor is used to hold the mandibular condyle inferiorly. The anterior meatal wall is removed, and drilling is advanced far inferiorly. DR, digastric ridge; MF, mandibular fossa; MFP, middle fossa plate; R, Fisch's retractor; SS, sigmoid sinus.

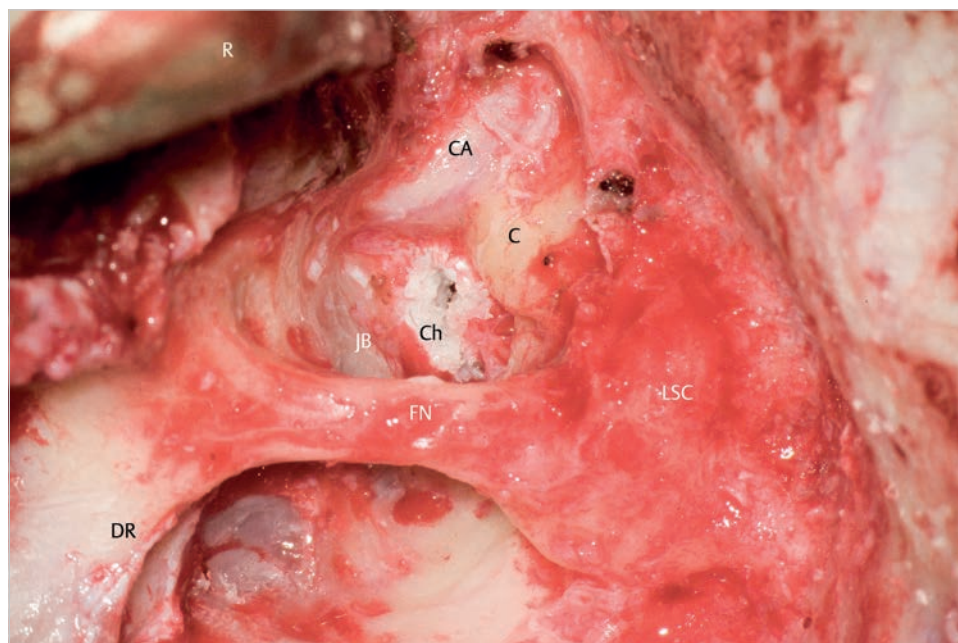


Fig. 14.489 Removal of the hypotympanic cells exposed the cholesteatoma under the cochlea infiltrating the hypotympanic cells. Under the facial nerve, eminence of the jugular bulb is seen. C, cochlea; CA, carotid artery; Ch, cholesteatoma; DR, digastric ridge; FN, facial nerve; JB, jugular bulb; LSC, lateral semicircular canal; R, Fisch's retractor.

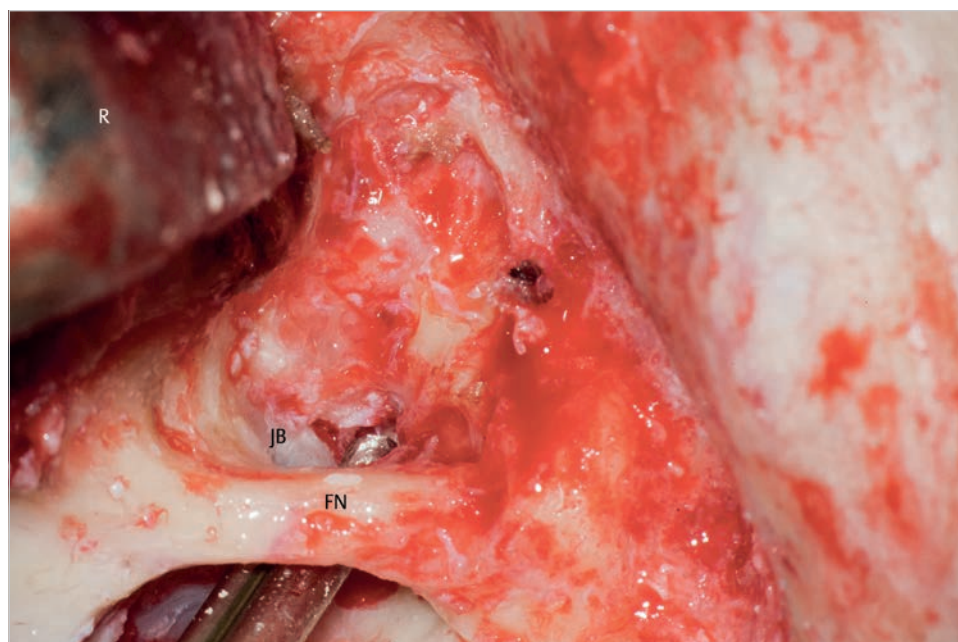


Fig. 14.490 Since the jugular bulb is not very large, another access to reach the cholesteatoma can be established between the facial nerve and the jugular bulb. FN, facial nerve; JB, jugular bulb; R, Fisch's retractor.

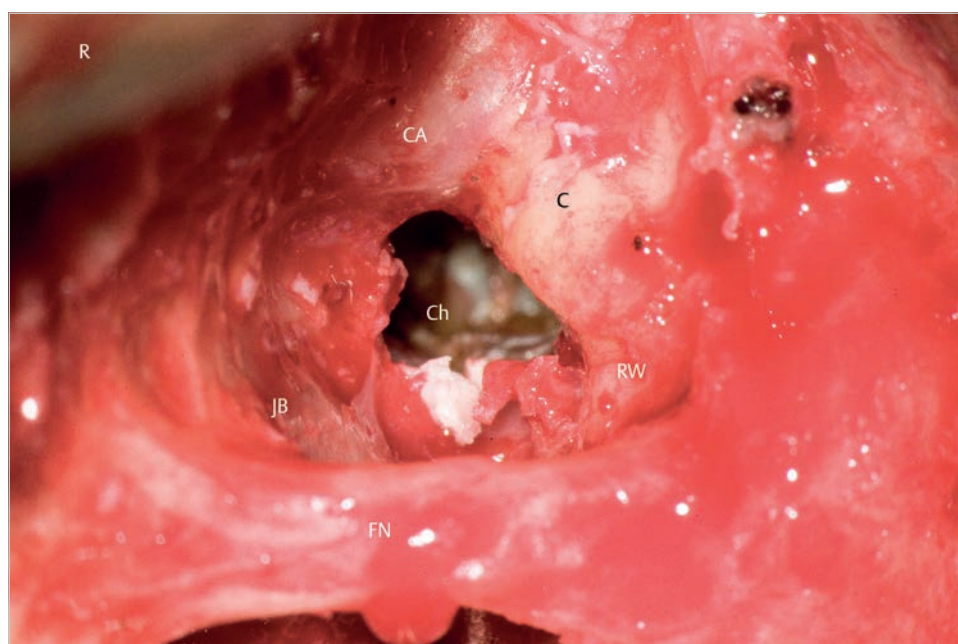


Fig. 14.491 The access to the petrous apex through the hypotympanic cell is limited by the cochlea superiorly, the carotid artery anteriorly, the jugular bulb inferiorly, and the facial nerve posteriorly. C, cochlea; CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; JB, jugular bulb; R, Fisch's retractor; RW, round window.

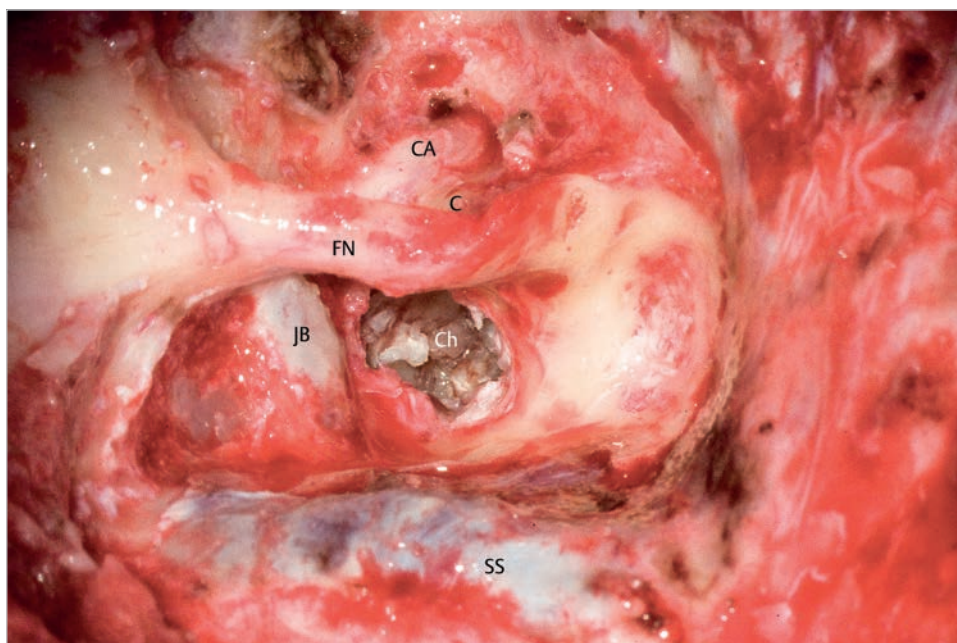


Fig. 14.492 The cochlea and the semicircular canals are partially drilled. Access to the petrous apex under the facial nerve is limited by the posterior labyrinth (posterior semicircular canal) superiorly, the facial nerve anteriorly, the jugular bulb inferiorly, the posterior fossa dura posteriorly. C, cochlea; CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; JB, jugular bulb; SS, sigmoid sinus.



Fig. 14.493 The deep lumen of the cholesteatoma is seen from the opening created under the facial nerve. Because of the limited access to the cholesteatoma, removal of the semicircular canals is indicated. Ch, cholesteatoma; JB, jugular bulb; FN, facial nerve.



Fig. 14.494 To drill the area anterior to the carotid artery, that is, the medial face of the mandibular fossa, the temporomandibular joint is pushed inferiorly and held with a Fisch infratemporal fossa retractor. CA, carotid artery; MFD, middle fossa dura; R, Fisch's retractor.

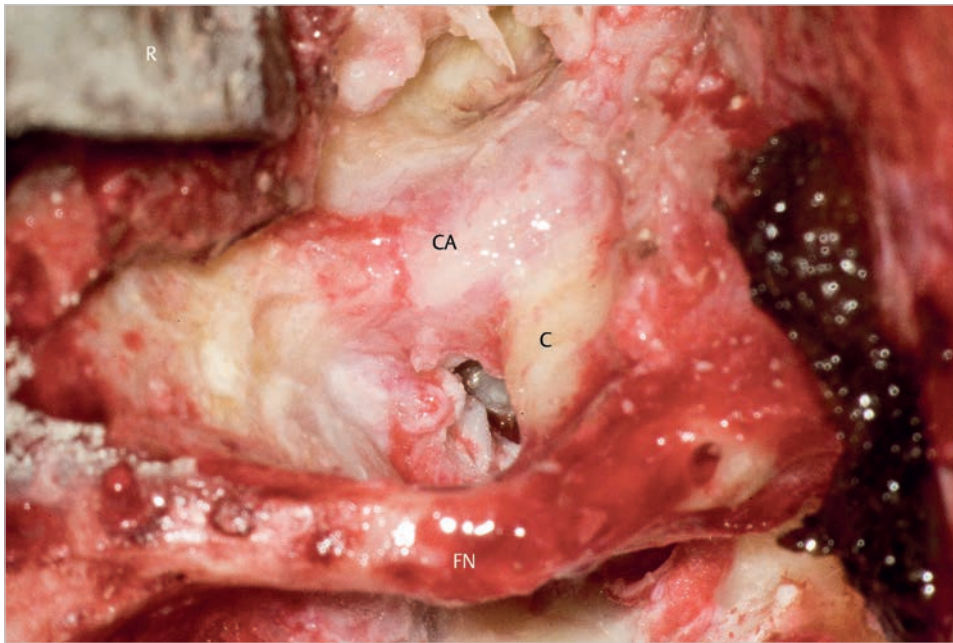


Fig. 14.495 The bone anteriorly to the carotid artery is started to be drilled. The size of the approach under the cochlea is not large enough to remove the cholesteatoma. Because of heavy involvement of preoperatively paralyzed facial nerve by the cholesteatoma, amputation of the damaged segment of the nerve followed by reconstruction is indicated. C, cochlea; CA, carotid artery; FN, facial nerve; R, Fisch's retractor.

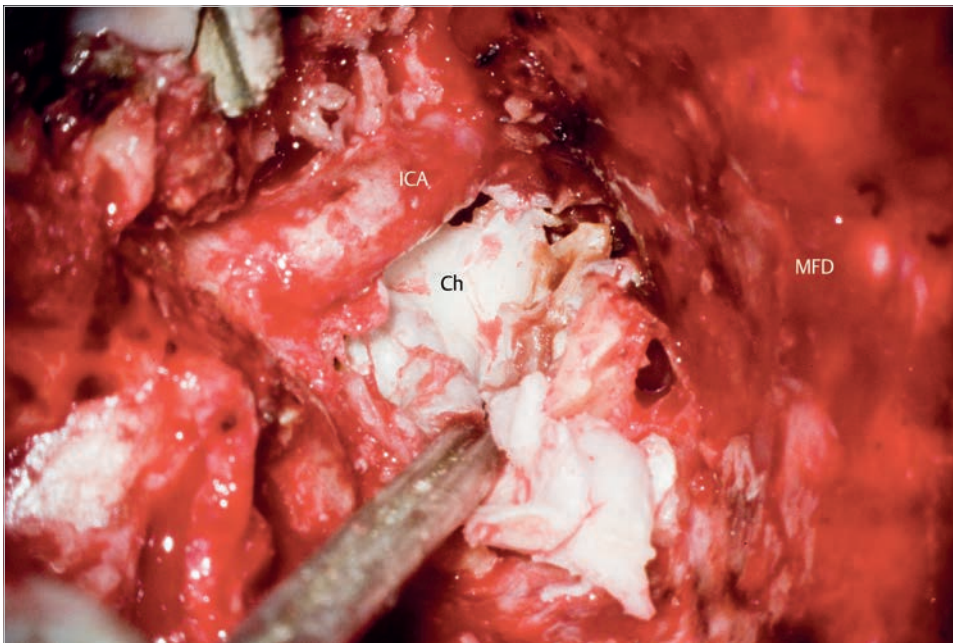


Fig. 14.496 By cutting the facial nerve with total removal of the labyrinth and removing the bone anteriorly to the carotid artery, the approach is enlarged to establish maximal surgical view to permit sufficient access for cholesteatoma removal from the petrous apex. Ch, cholesteatoma; ICA, internal carotid artery; MFD, middle fossa dura.

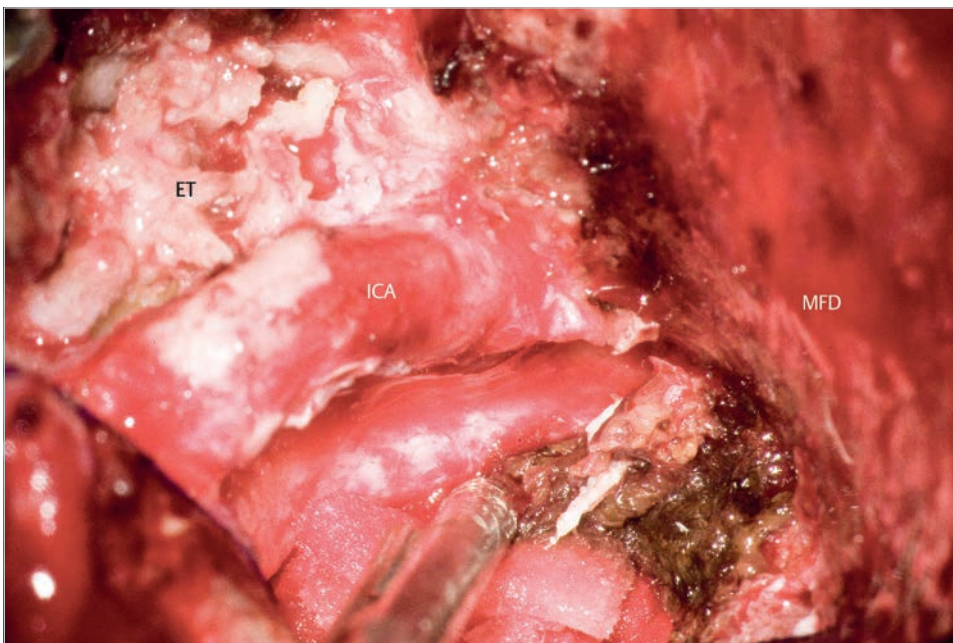


Fig. 14.497 The anterior bony wall of the petrous apex free of cholesteatoma is shown. Connective tissue around the cartilaginous portion of the eustachian tube is located anteriorly to the internal carotid artery. ET, eustachian tube; ICA, internal carotid artery; MFD, middle fossa dura.

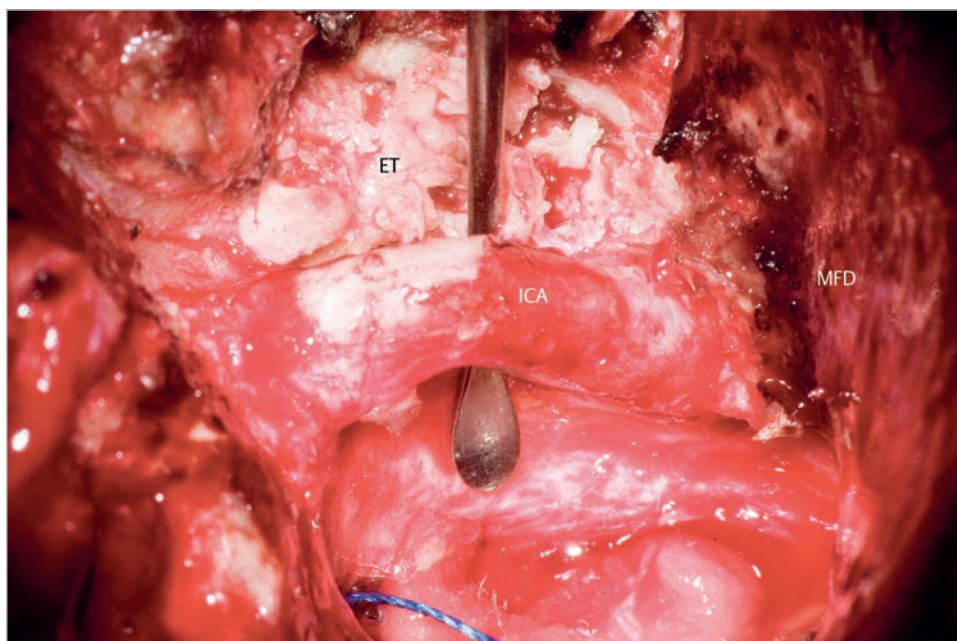


Fig. 14.498 The opening medially to the mandibular fossa created by removing the bone anterior to the carotid artery is shown. ET, eustachian tube; ICA, internal carotid artery; MFD, middle fossa dura.

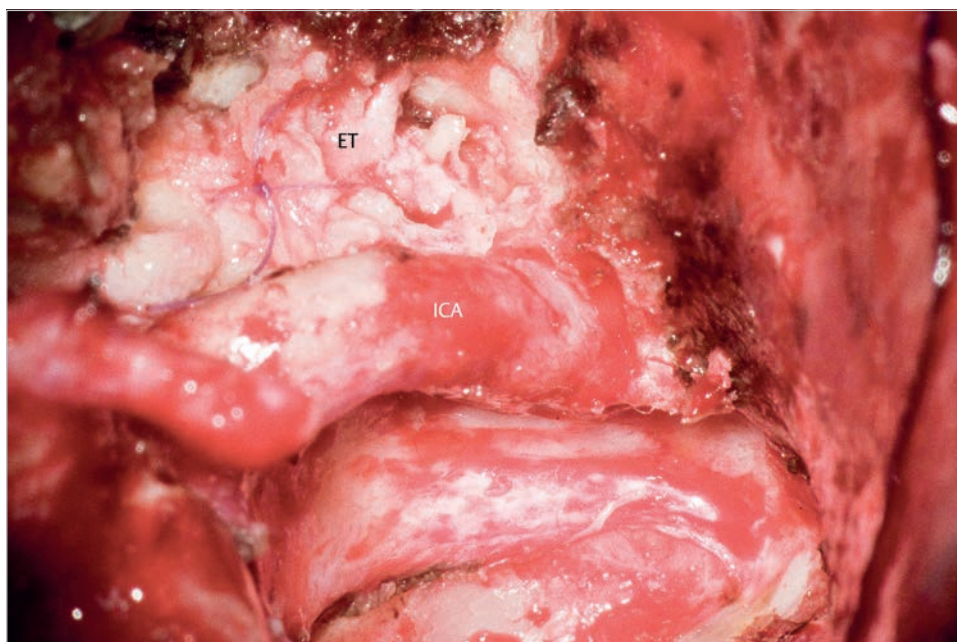


Fig. 14.499 A wide access to the petrous apex established with this approach is shown. ET, eustachian tube; ICA, internal carotid artery.

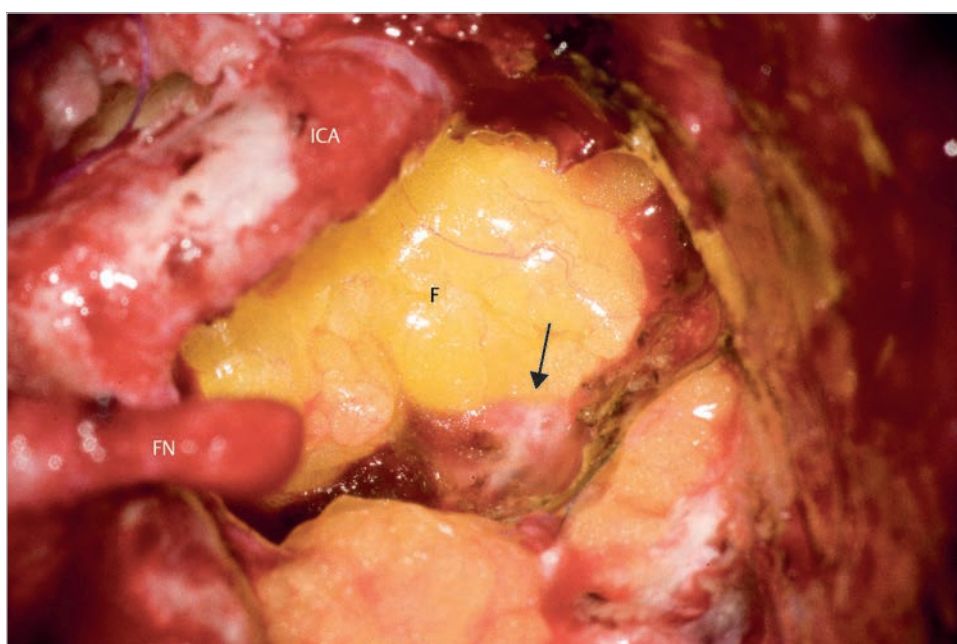


Fig. 14.500 The cavity is partially obliterated with abdominal fat, but the porus of the internal auditory canal (*arrow*) is left open. F, abdominal fat; FN, facial nerve; ICA, internal carotid artery.

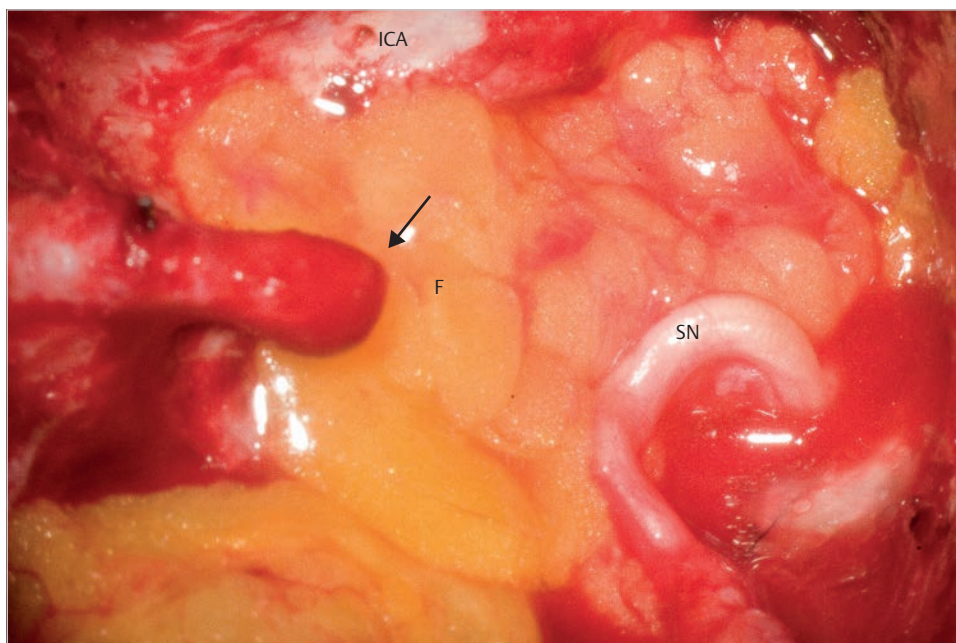


Fig. 14.501 The sural nerve is used as a graft to reconstruct the facial nerve. The proximal stump of the facial nerve is fixed with fibrin glue. Distal stump is seen inferiorly (*arrow*). F, abdominal fat; ICA, internal carotid artery; SN, sural nerve graft.

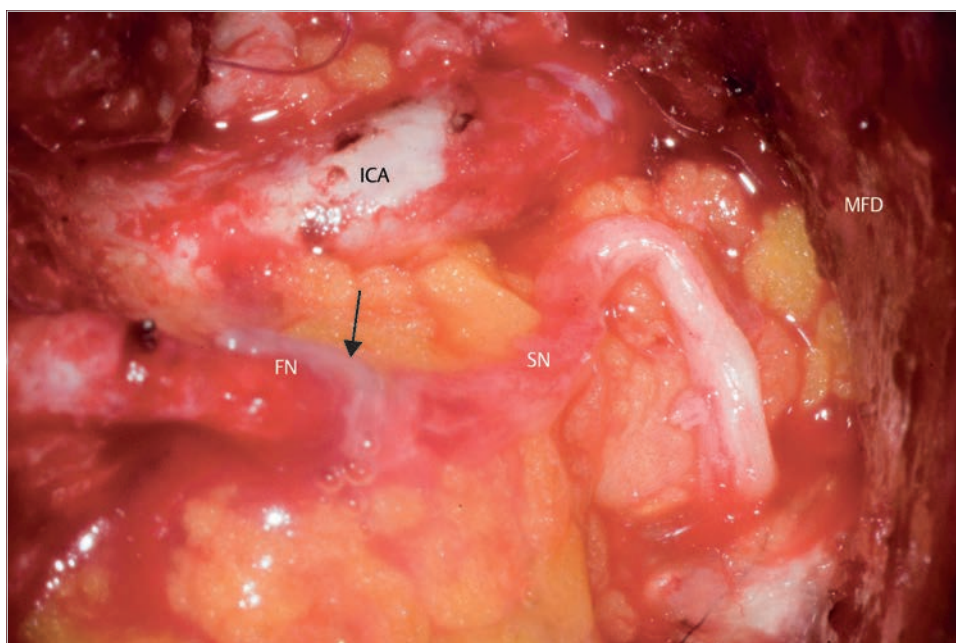


Fig. 14.502 Reconstruction of the facial nerve is accomplished. The distal stump is fixed with fibrin glue (*arrow*), and the junction is covered with a piece of fascia. FN, facial nerve; ICA, internal carotid artery; MFD, middle fossa dura; SN, sural nerve graft.

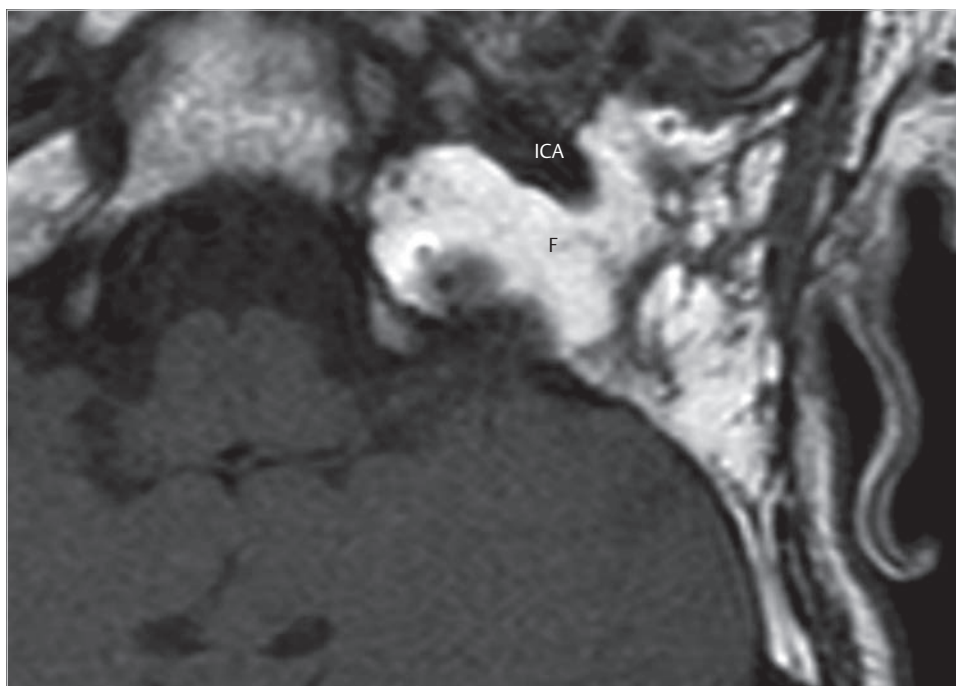


Fig. 14.503 Postoperative MRI shows extensive removal of bone from the petrous apex lesion, and from the area anterior to the carotid artery. ICA, carotid artery; F, abdominal fat.

Case 14.21 (Right Ear)

See ▶Fig. 14.504, ▶Fig. 14.505, ▶Fig. 14.506, ▶Fig. 14.507, ▶Fig. 14.512, ▶Fig. 14.513, ▶Fig. 14.514, ▶Fig. 14.515, ▶Fig. 14.508, ▶Fig. 14.509, ▶Fig. 14.510, ▶Fig. 14.511, ▶Fig. 14.516, ▶Fig. 14.517.

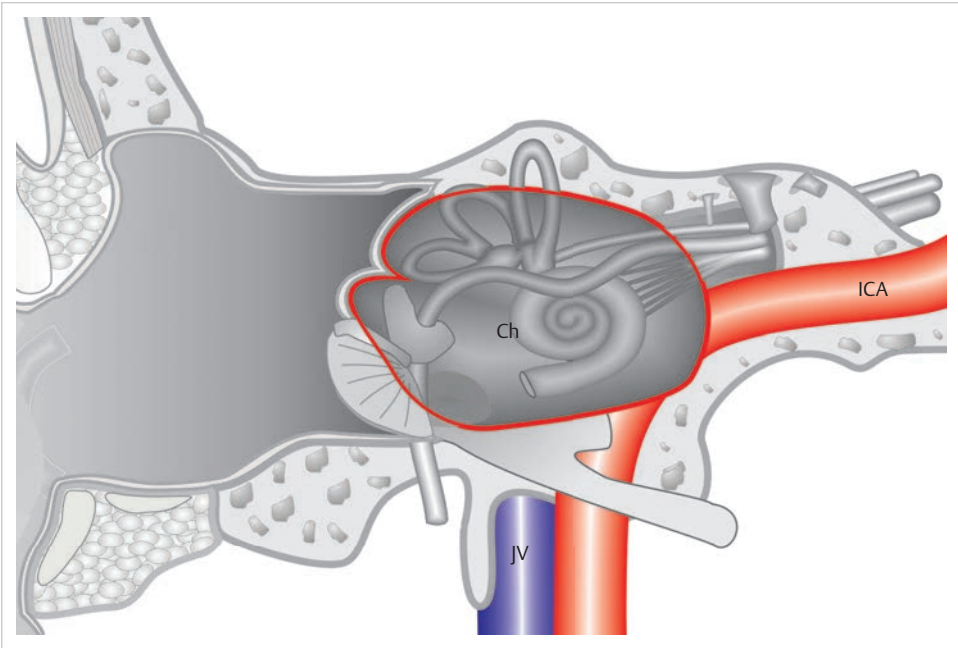


Fig. 14.504 A case of massive petrous bone cholesteatoma in a formerly performed open cavity treated with transotic approach. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

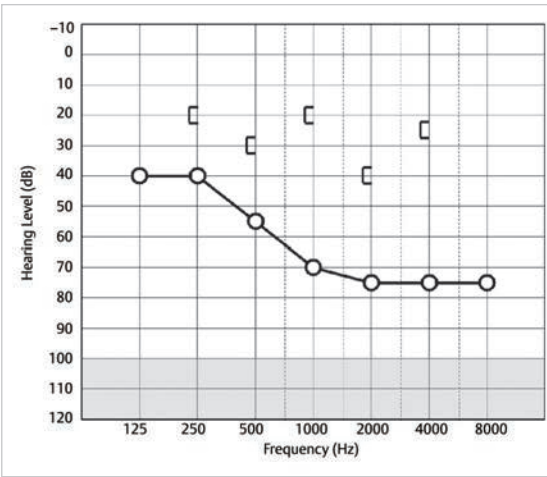


Fig. 14.505 The patient suffered from right otorrhea since 20 years ago, and undertook six operations elsewhere. The patient developed dizziness and tinnitus with persistent otorrhea for 6 years. Preoperative hearing examination showed mixed hearing loss with considerable air–bone gap. Otoscopy revealed whitish bulging in the area of the labyrinth, suggesting recurrence of cholesteatoma. The tympanic membrane is inflamed and lateralized. The facial nerve function remained normal preoperatively.

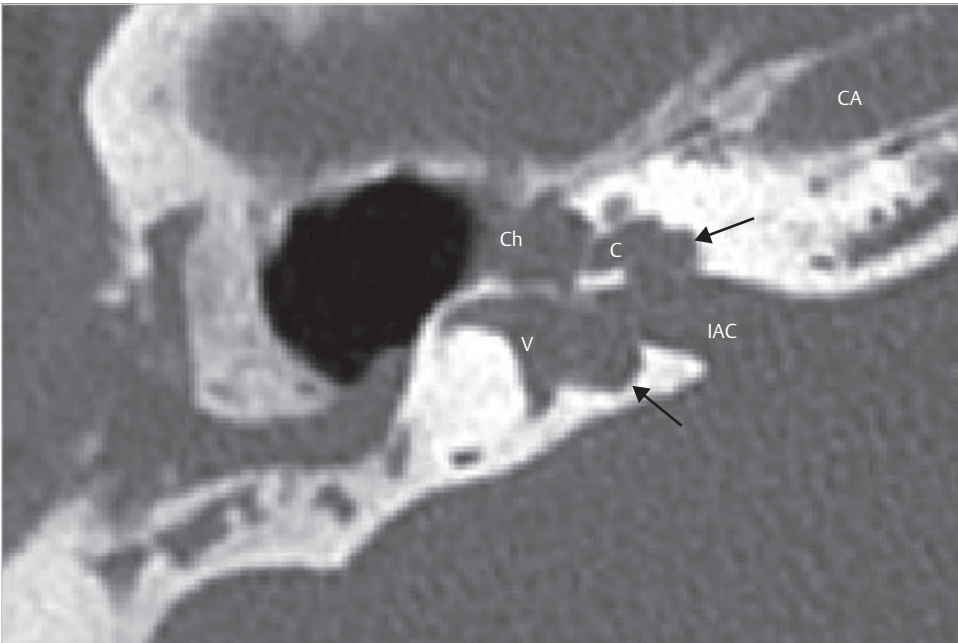


Fig. 14.506 Despite fair bone conduction, the axial CT at the level of the internal auditory canal shows erosion of both the cochlea and the vestibule by the cholesteatoma extended medially to the labyrinth. C, cochlea; CA, carotid artery; Ch, cholesteatoma; IAC, internal auditory canal; V, vestibule.

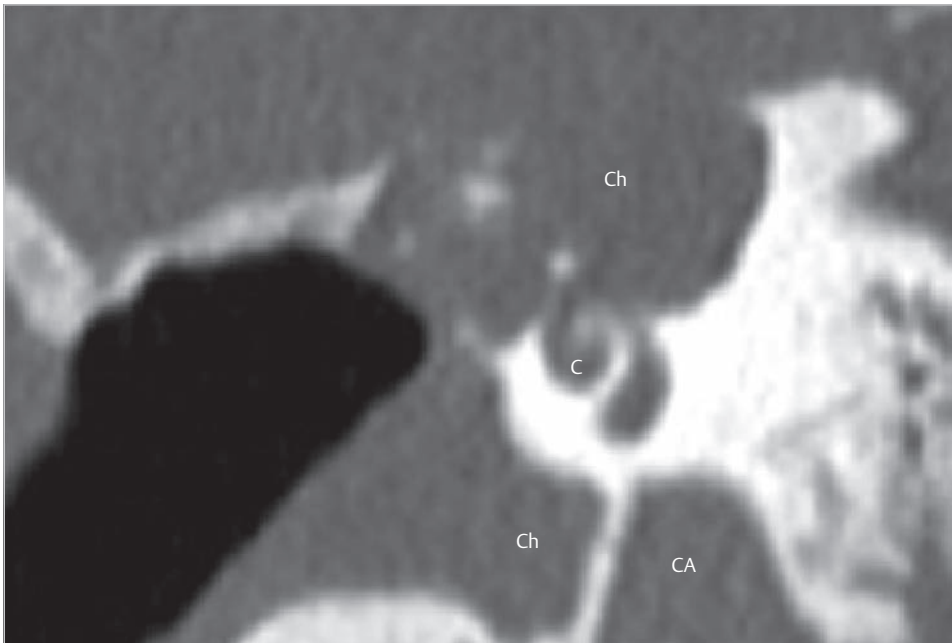


Fig. 14.507 The coronal CT shows heavy erosion of the cochlea and extensive exposure of the middle fossa dura. The geniculate ganglion and the labyrinthine segment of the facial nerve are totally engulfed by cholesteatoma. The tympanic cavity is filled with soft tissue, and hypotympanic cells are eroded suggesting presence of cholesteatoma also in the hypotympanum. C, cochlea; CA, carotid artery; Ch, cholesteatoma.

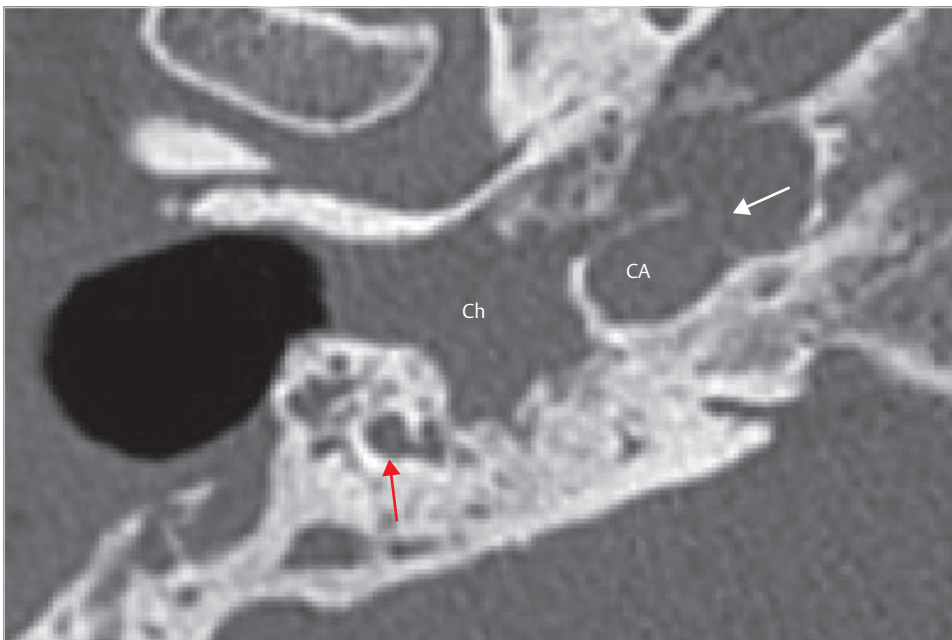


Fig. 14.508 The hypotympanic area filled with soft tissue density is shown. The tympanic membrane is lateralized, and bone erosion is suspected in the anterior face of the vertical segment of the carotid canal (*white arrow*). The red arrow indicates the mastoid segment of the facial nerve. CA, carotid artery (vertical segment); Ch, cholesteatoma.

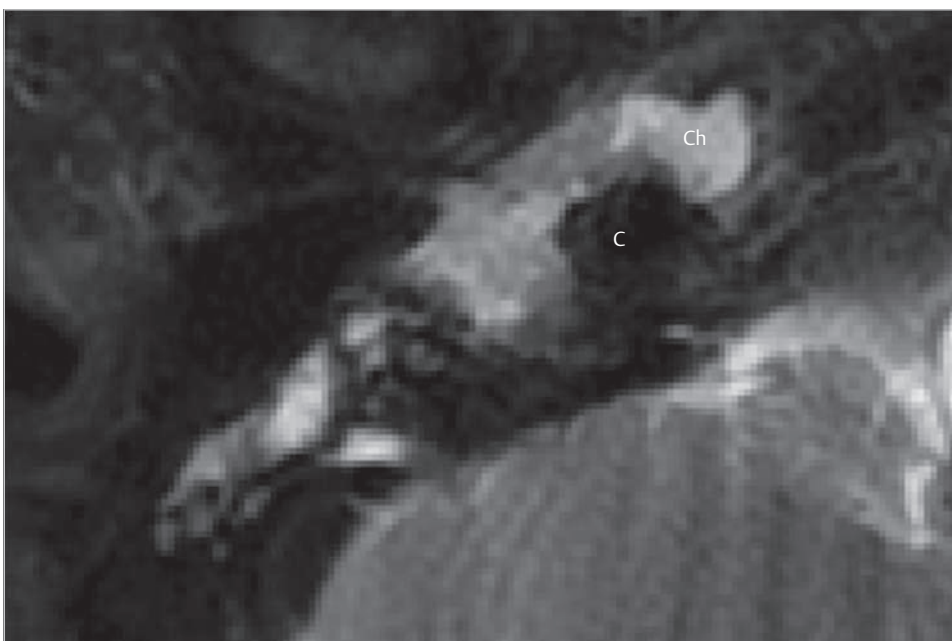


Fig. 14.509 The axial T2-weighted image of MRI at the same level of ► Fig. 14.508 demonstrated high signal intensity around the flow void of the carotid artery suggesting medial extension of cholesteatoma in the infralabyrinthine region. C, cochlea; Ch, cholesteatoma.

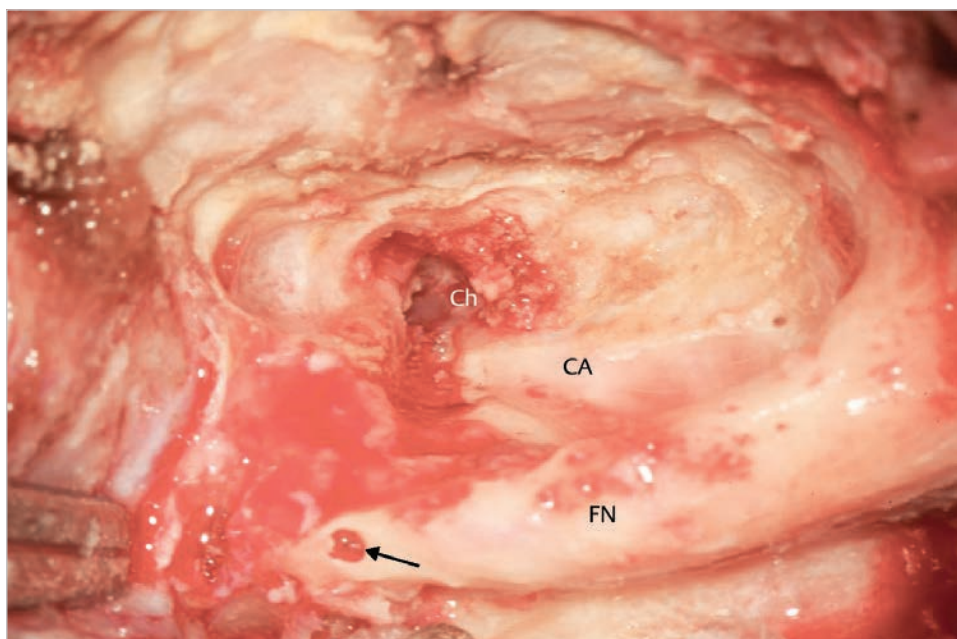


Fig. 14.510 The skin covering the cavity is removed, and posterior face of the temporomandibular joint is exposed. The dura of the middle and the posterior fossae is uncovered, and the facial nerve is skeletonized. A labyrinthectomy is ongoing. An opening of the lateral semicircular canals is seen (*black arrow*). The tympanic bone and infiltrated hypotympanic cells are extensively removed to control the vertical segment of the carotid artery. Cholesteatoma located medially to the vertical segment is seen. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

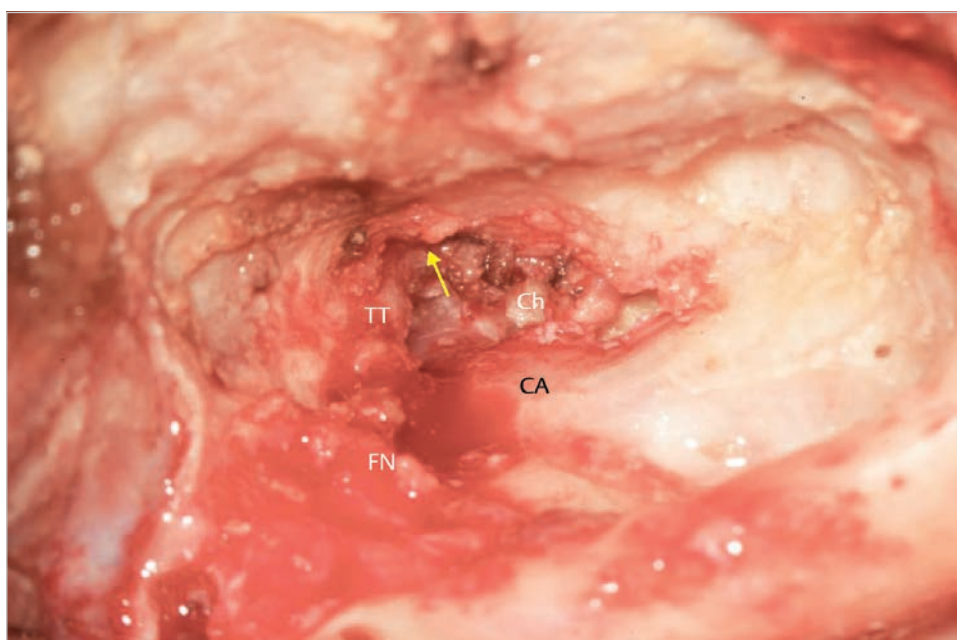


Fig. 14.511 Cholesteatoma infiltrating the space anteromedially to the vertical segment of the carotid artery is shown. The eustachian tube is identified (*arrow*) laterally to the cholesteatoma. The tensor tympani muscle forms superior wall of it. The tympanic segment of the nerve is covered with granulation tissue. The inferior half of the cochlea has already been drilled to establish access to the horizontal segment of the carotid artery. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; TT, tensor tympani.

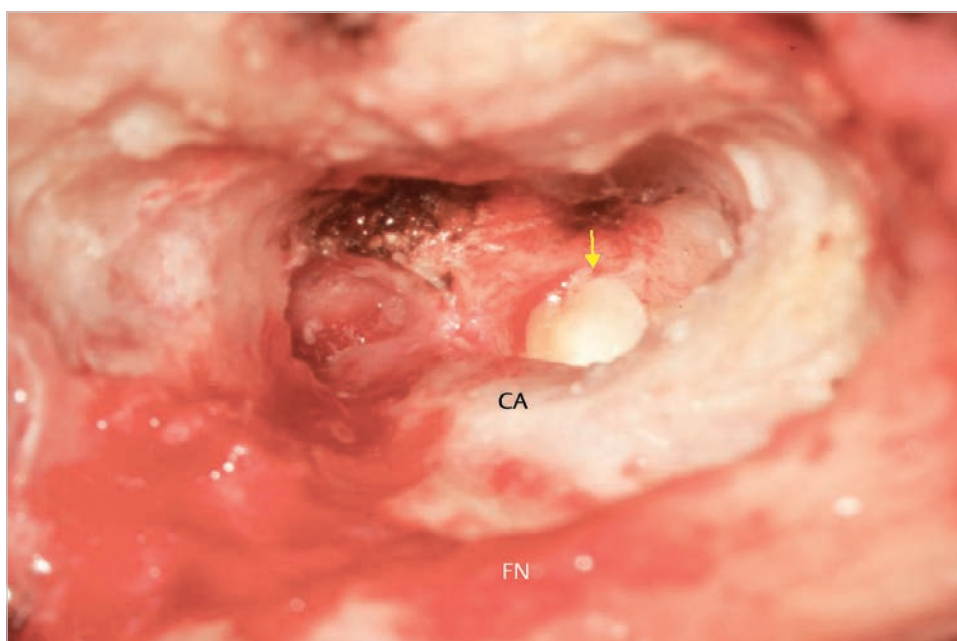


Fig. 14.512 To control the area medially to the vertical segment of the carotid artery, the horizontal segment is followed medially by transecting the tensor tympani muscle, and further drilling the cochlea and the medial wall of the protympanum. Cholesteatoma infiltrating that area is seen (*arrow*). CA, carotid artery; FN, facial nerve.

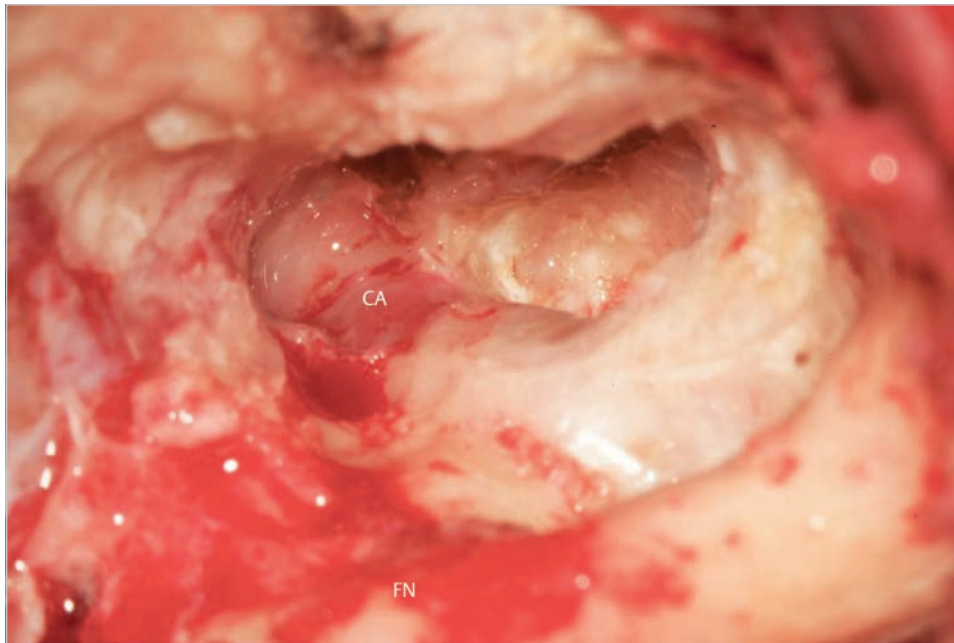


Fig. 14.513 Cholesteatoma extended anteromedially to the carotid artery is removed. CA, carotid artery (horizontal segment); FN, facial nerve.

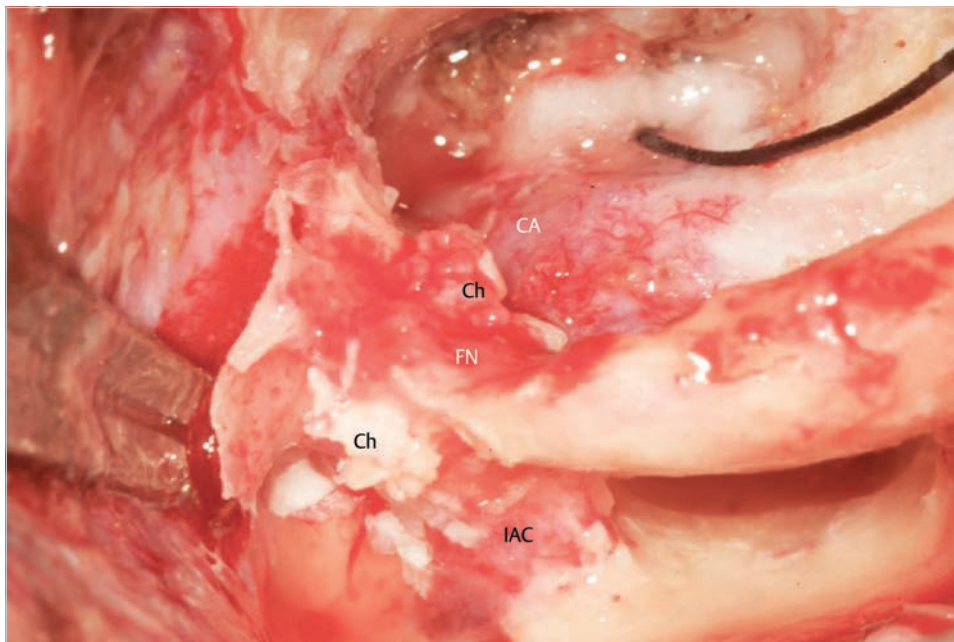


Fig. 14.514 Cholesteatoma infiltrating the cochlea to pass under the facial nerve is shown. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve (tympanic segment); IAC, internal auditory canal.

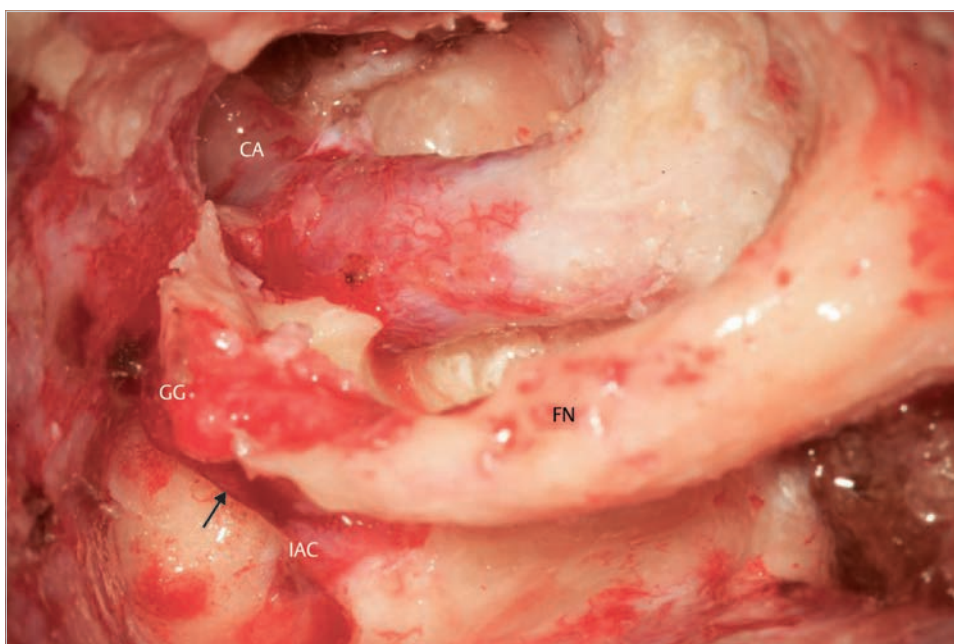


Fig. 14.515 The cholesteatoma eroding the medial face of the otic capsule and the internal auditory canal is removed leaving the facial nerve in place. Eradication of the cholesteatoma is completed. The labyrinthine segment of the facial nerve is indicated by an arrow. CA, carotid artery (horizontal segment); FN, facial nerve (mastoid segment); GG, geniculate ganglion; IAC, internal auditory canal.

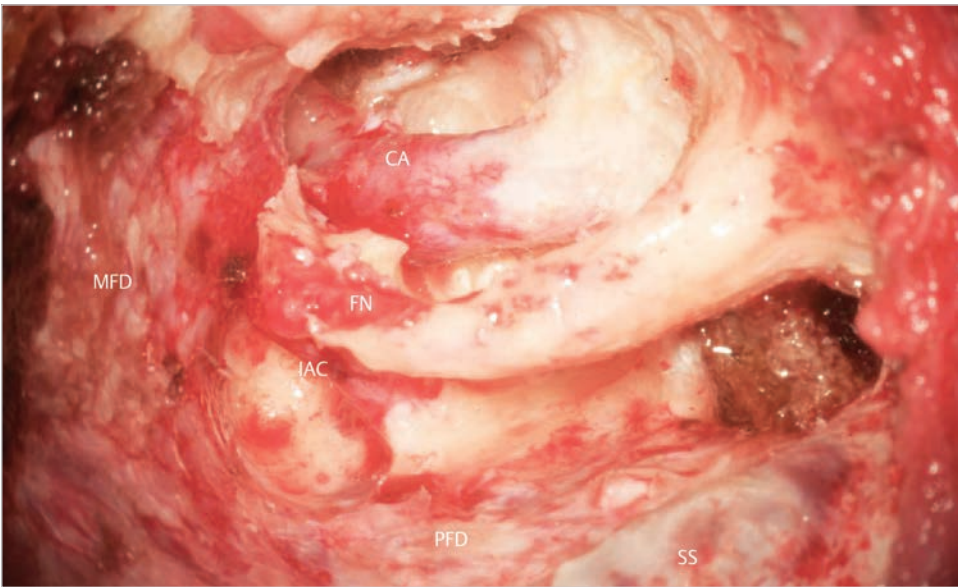


Fig. 14.516 The final shape of the cavity is shown. Note that the middle fossa dura and the posterior fossa dura are widely exposed to gain access to the area over superiorly to the internal auditory canal, and to control the area anteriorly to the carotid artery. The eustachian tube is packed with pieces of periosteum, and the cavity is packed with abdominal fat. CA, carotid artery; FN, facial nerve; IAC, internal auditory canal; MFD, middle fossa dura; PFD, posterior fossa dura; SS, sigmoid sinus.

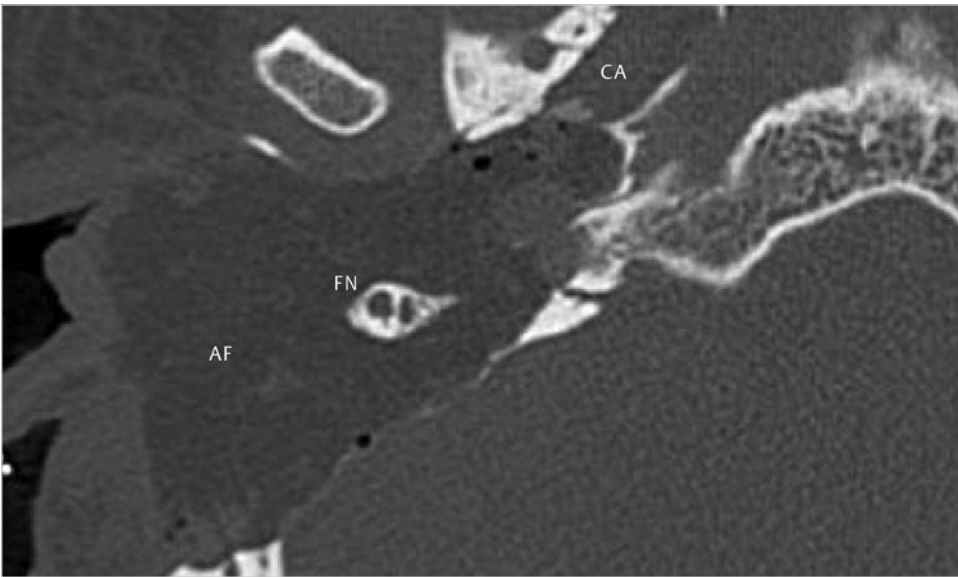


Fig. 14.517 The postoperative CT shows shape of the cavity is shown. Access to the area of the carotid artery is widened by exposing the temporomandibular joint anteriorly, and the posterior fossa dura posteriorly. Preservation of the fallopian canal at the level of the mastoid segment and exposure of the carotid artery is demonstrated. AF, abdominal fat; CA, carotid artery; FN, facial nerve.

Case 14.22 (Left Ear)

See ▶Fig. 14.518, ▶Fig. 14.519, ▶Fig. 14.520, ▶Fig. 14.521, ▶Fig. 14.522, ▶Fig. 14.523, ▶Fig. 14.524, ▶Fig. 14.525, ▶Fig. 14.526, ▶Fig. 14.527, ▶Fig. 14.528, ▶Fig. 14.529, ▶Fig. 14.530, ▶Fig. 14.531.

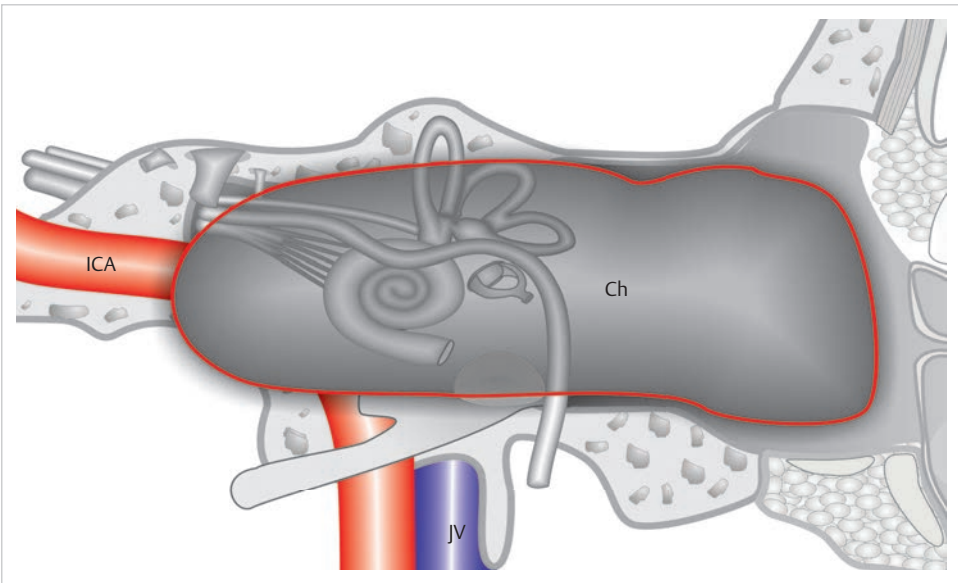


Fig. 14.518 A case of massive petrous bone cholesteatoma formerly treated with posterior fossa approach and reoperated with transotic approach. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular bulb.

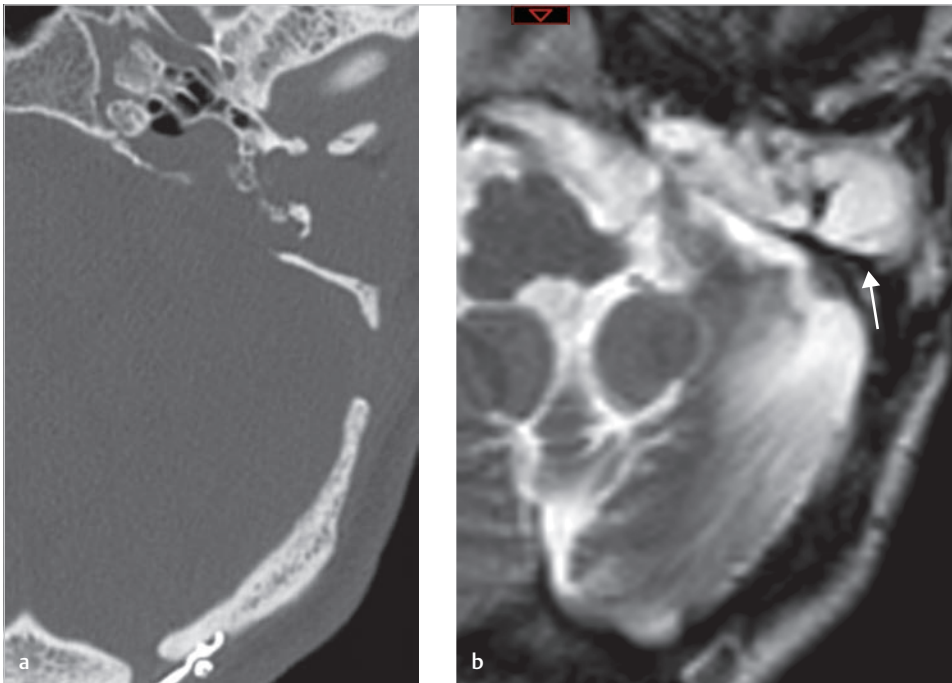


Fig. 14.519 The patient suffered from meningitis with facial weakness with dead ear 2 years before and underwent two surgeries elsewhere through transmastoid and retrosigmoid approaches. The axial CT (a) shows incomplete access to the petrous apex from both lateral and posterior, and the T2-weighted MRI (b) demonstrated large ischemic change in left cerebellar hemisphere due to compression during retrosigmoid approach. Recurrent cholesteatoma filling the temporal bone is demonstrated in high signal (arrow).

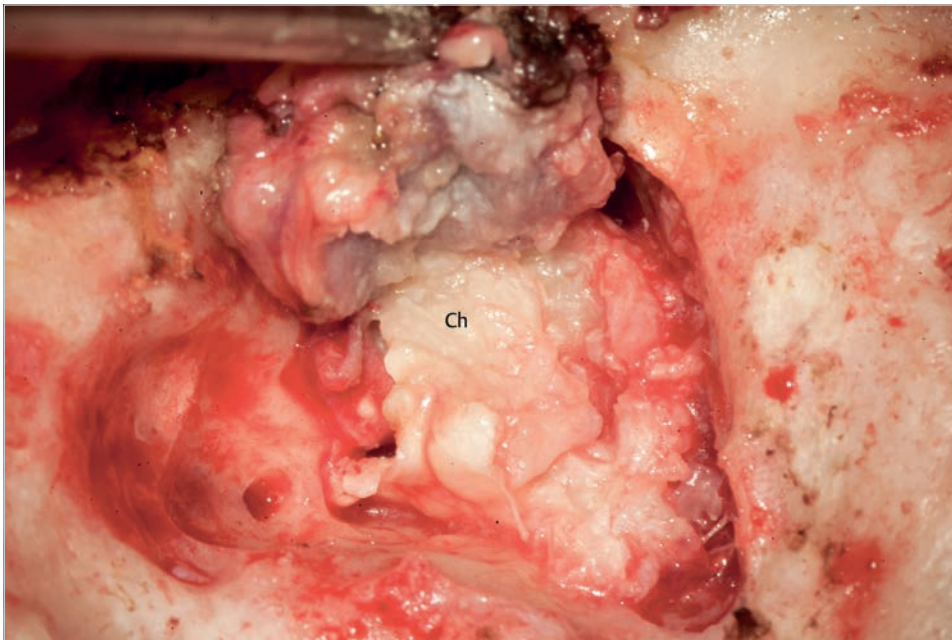


Fig. 14.520 The external auditory canal has already been closed in the former surgery. Scar tissue filling the tympanic and mastoid cavity is reduced, and the cholesteatoma is opened from lateral. Ch, cholesteatoma.

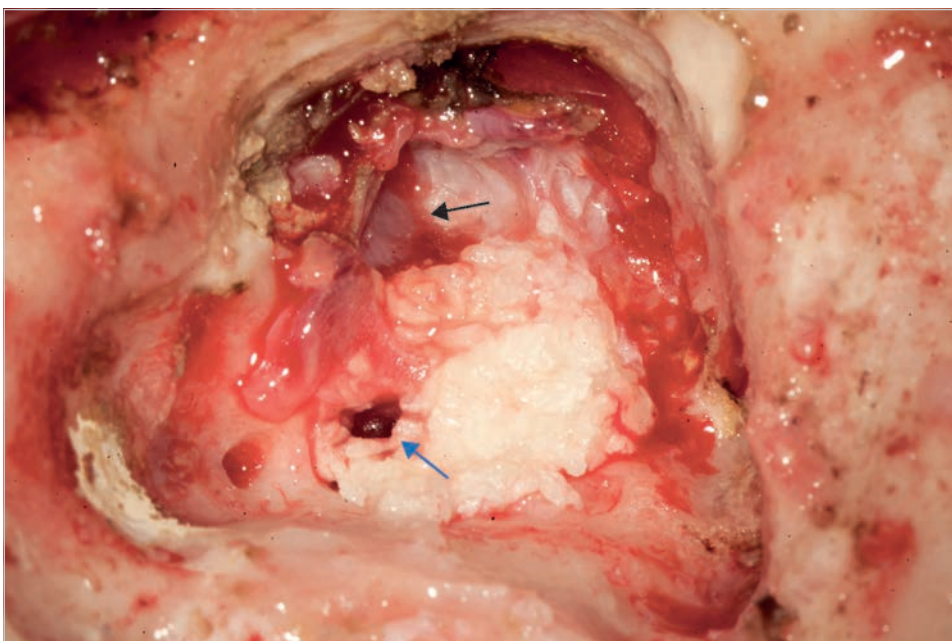


Fig. 14.521 Debris is partially evacuated. A route toward the petrous apex is identified (blue arrow), and granulation tissue covering the hypotympanic area is exposed (black arrow).

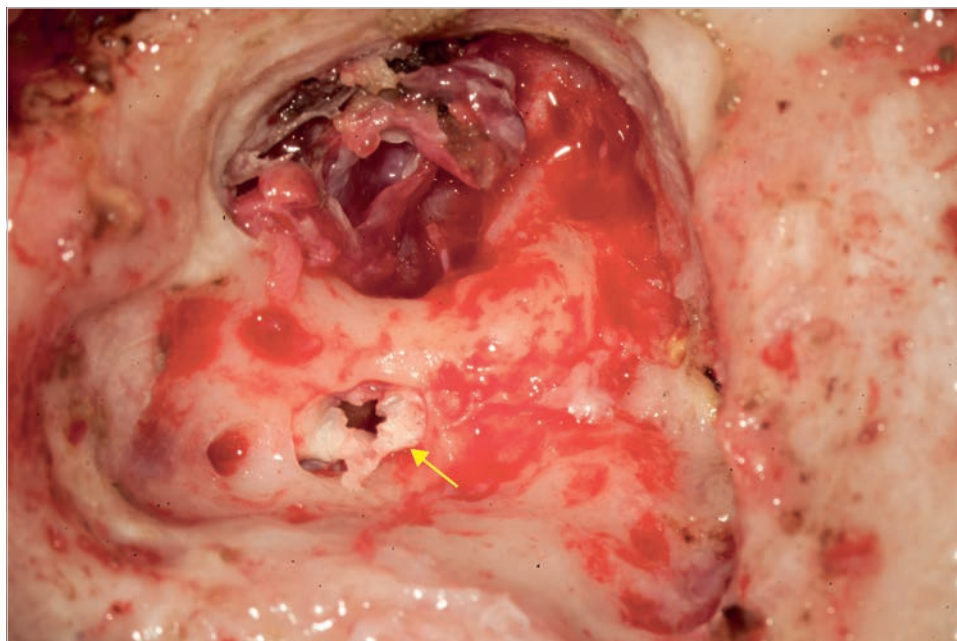


Fig. 14.522 The cholesteatoma in the mastoid has continuity to the petrous apex region through the retrofacial cells (*arrow*). Scar tissue covering the medial wall of the tympanic cavity is reflected inferiorly.

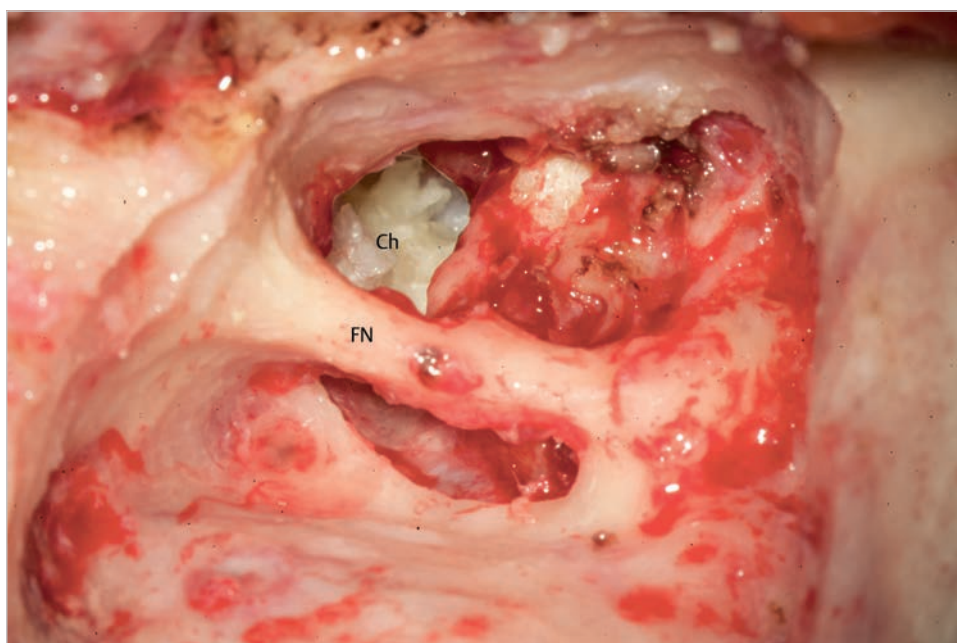


Fig. 14.523 Removal of the granulation tissue covering the hypotympanic area revealed cholesteatoma occupying the petrous apex. The facial nerve is skeletonized, and the retrofacial cells are started to be removed to enlarge the approach. Ch, cholesteatoma; FN, facial nerve.

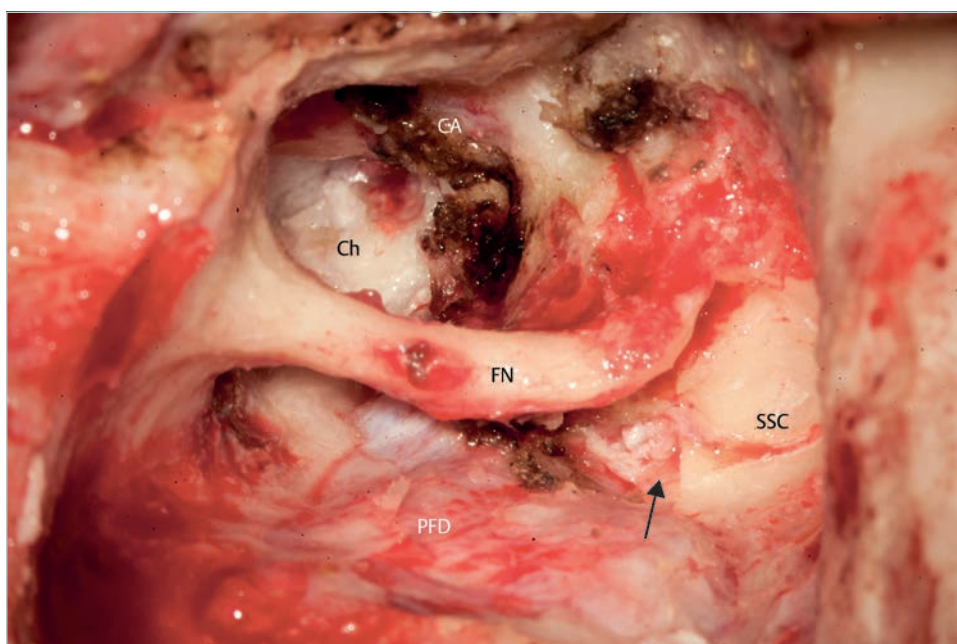


Fig. 14.524 The inferior part of the cochlea is removed, and the carotid artery is skeletonized to enlarge the approach anteriorly to the facial nerve. The posterior fossa dura is exposed and followed medially and superiorly. The posterior and the lateral semicircular canals are removed, and the superior semicircular canal is opened. Cholesteatoma infiltrating medially to the posterior labyrinth is started to be seen (*arrow*). CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; PFD, posterior fossa dura; SSC, superior semicircular canal.

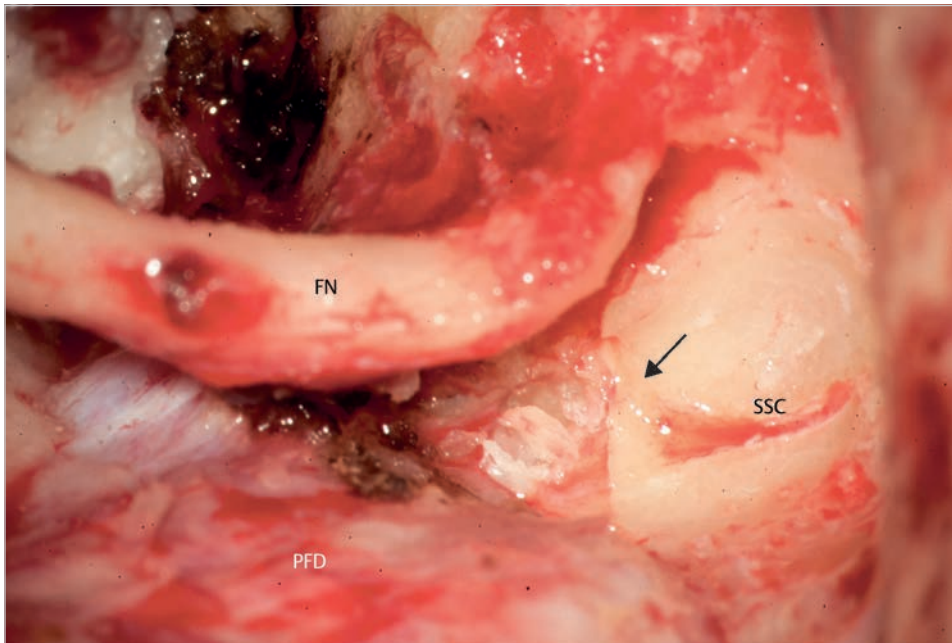


Fig. 14.525 Cholesteatoma located medially to the common crus (*arrow*) is shown. FN, facial nerve; PFD, posterior fossa dura; SSC, superior semicircular canal.

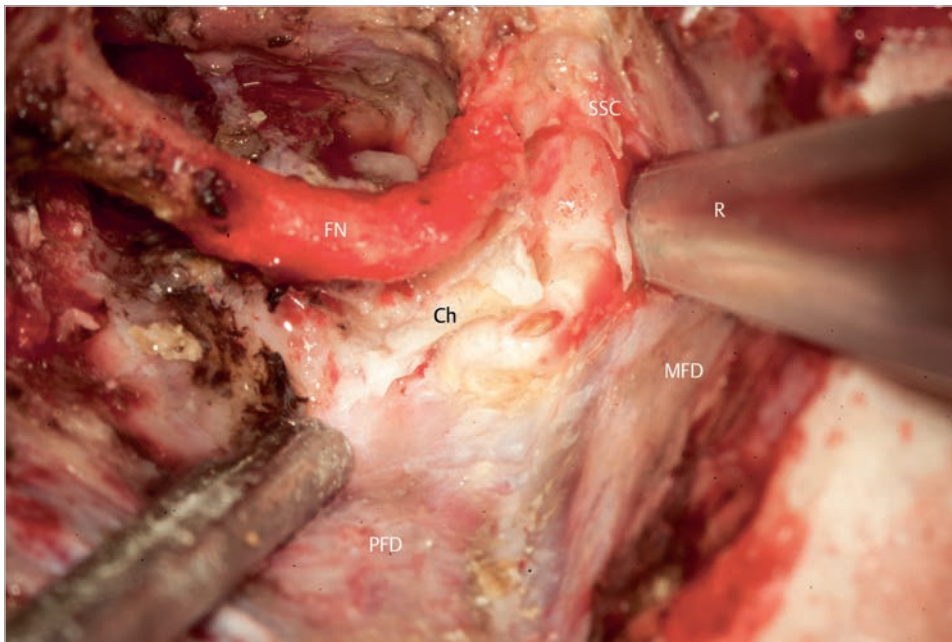


Fig. 14.526 Removal of the posterior half of the superior semicircular canal exposed cholesteatoma infiltrating between the internal auditory canal and the labyrinth. The middle fossa dura is maintained by a self-retaining retractor. Ch, cholesteatoma; FN, facial nerve; MFD, middle fossa dura; PFD, posterior fossa dura; R, self-retaining retractor; SSC, superior semicircular canal.

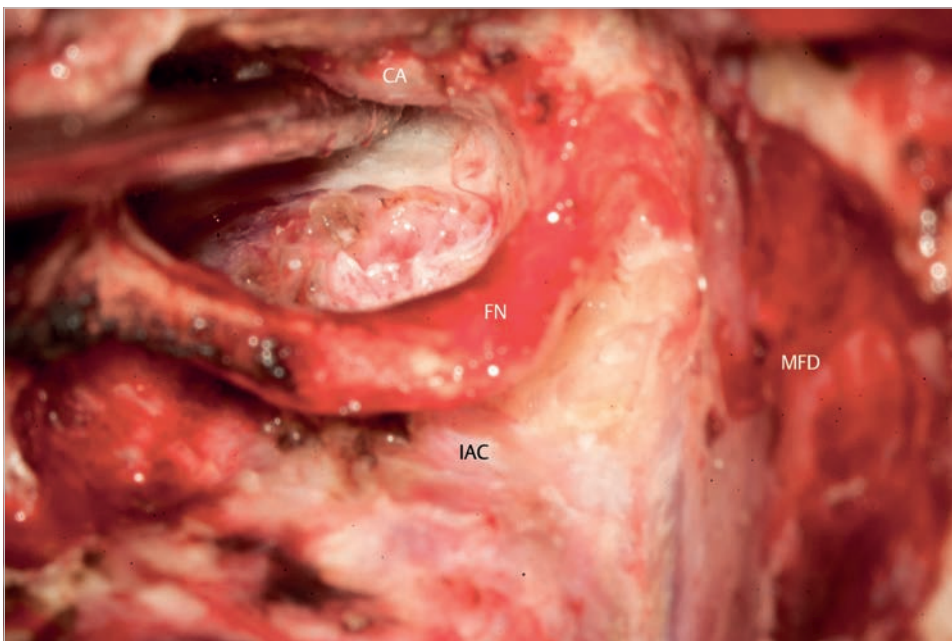


Fig. 14.527 The cholesteatoma infiltrating the area posterosuperior to the internal auditory canal is totally removed, and the matrix covering the carotid artery is removed. The suction tip is introduced to show access to the space medially to the carotid artery. CA, carotid artery; FN, facial nerve; IAC, internal auditory canal; MFD, middle fossa dura.



Fig. 14.528 The final shape of the cavity is shown. Sufficient access to this infracochlear-apical lesion is achieved by sufficiently skeletonizing the carotid artery and the facial nerve. CA, carotid artery; FN, facial nerve; IAC, internal auditory canal; SS, sigmoid sinus.

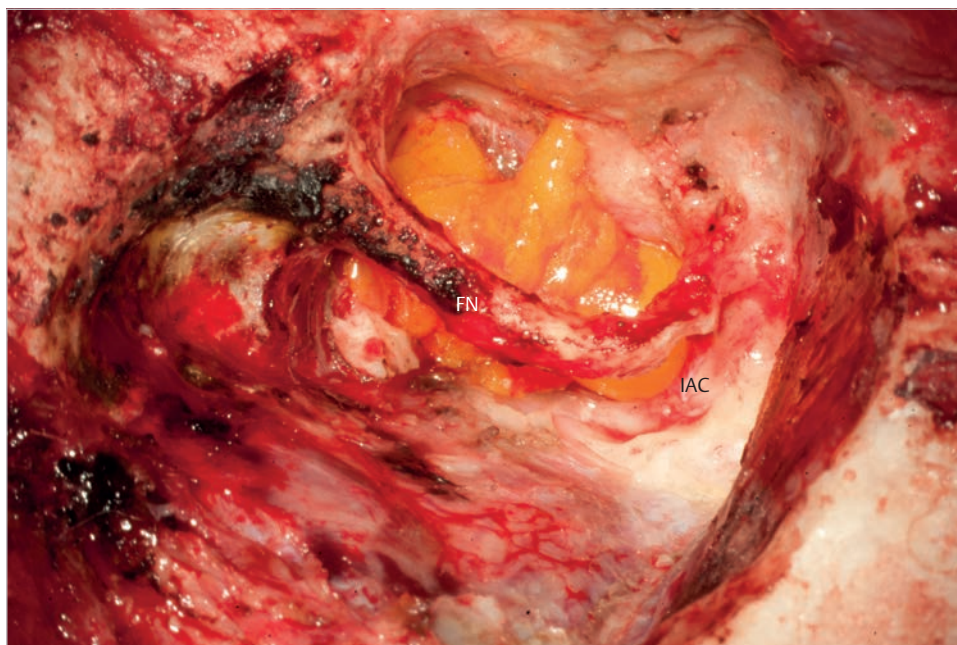


Fig. 14.529 The cavity is obliterated with abdominal fat, and the wound is closed in three layers. FN, facial nerve; IAC, internal auditory canal.

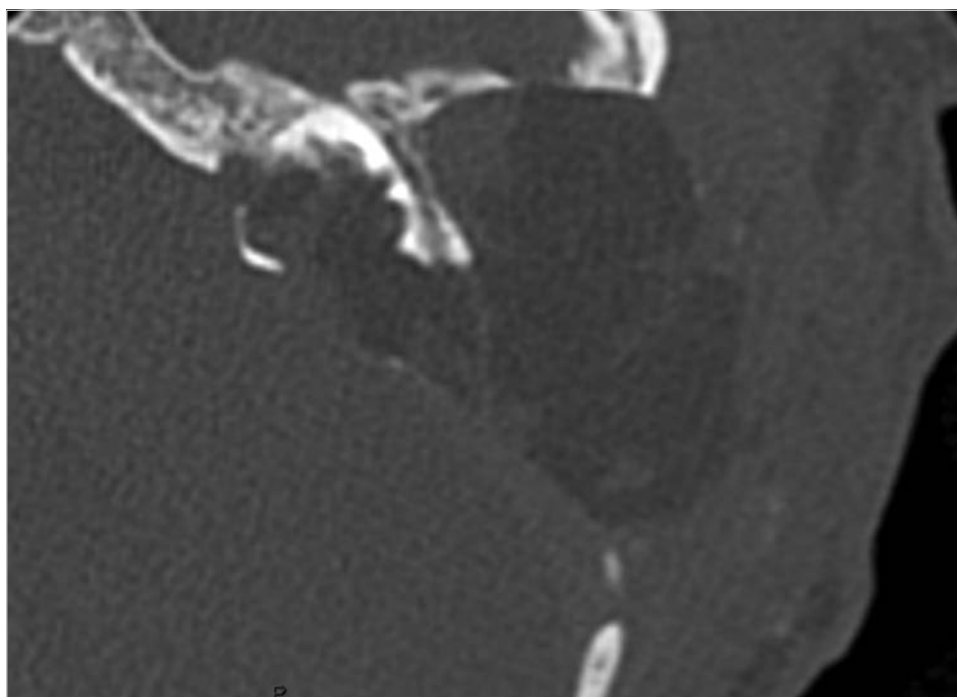


Fig. 14.530 Extensive removal of bone from the temporal bone is shown. A thin bony shell left around the tympanic segment of the facial nerve is seen (arrow).

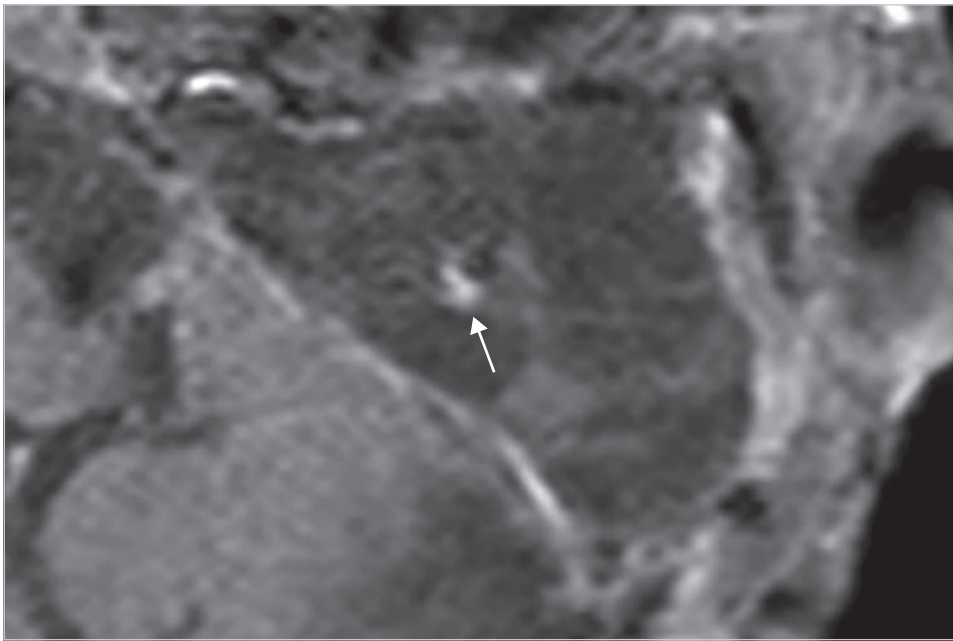


Fig. 14.531 Postoperative MRI 1 week after the surgery is shown. An enhancement of the facial nerve is seen (arrow) in the abdominal fat even though the facial nerve function of the patient remained H-B grade I.

Case 14.23 (Right Ear)

See ▶ Fig. 14.532, ▶ Fig. 14.533, ▶ Fig. 14.534, ▶ Fig. 14.535, ▶ Fig. 14.536, ▶ Fig. 14.537, ▶ Fig. 14.538, ▶ Fig. 14.539, ▶ Fig. 14.540, ▶ Fig. 14.541, ▶ Fig. 14.542, ▶ Fig. 14.543, ▶ Fig. 14.544, ▶ Fig. 14.545, ▶ Fig. 14.546, ▶ Fig. 14.547, ▶ Fig. 14.548, ▶ Fig. 14.549, ▶ Fig. 14.550, ▶ Fig. 14.551, ▶ Fig. 14.552, ▶ Fig. 14.553, ▶ Fig. 14.554, ▶ Fig. 14.555, ▶ Fig. 14.556, ▶ Fig. 14.557, ▶ Fig. 14.558, ▶ Fig. 14.559, ▶ Fig. 14.560, ▶ Fig. 14.561, ▶ Fig. 14.562.

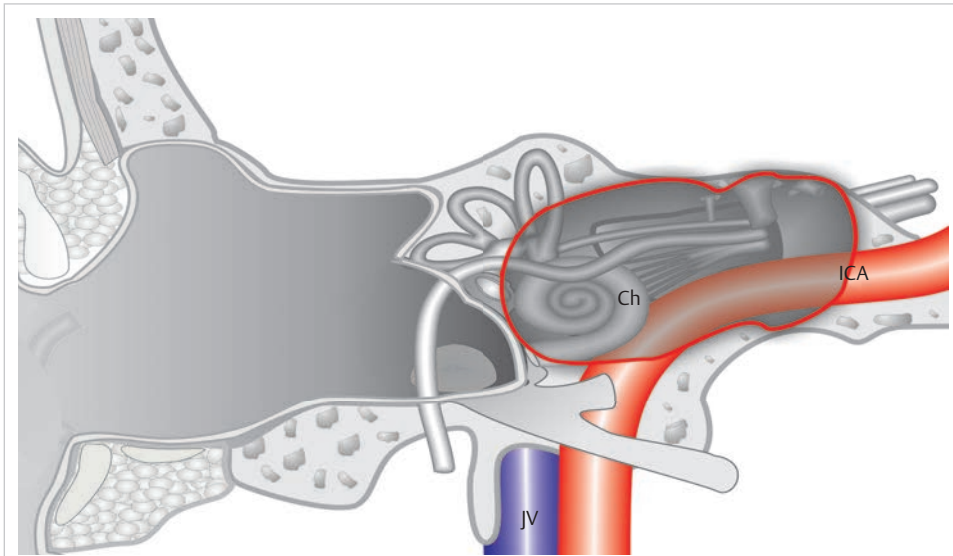


Fig. 14.532 A case of massive petrous bone cholesteatoma in canal wall down cavity treated with transotic approach. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

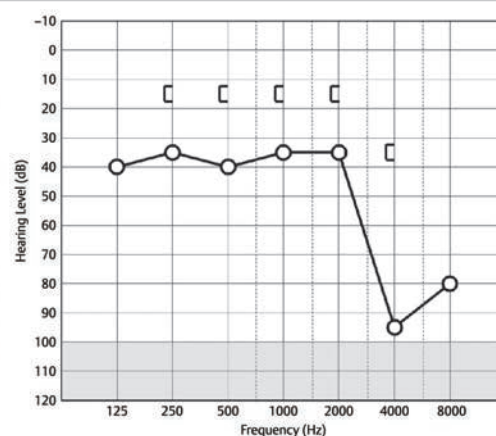


Fig. 14.533 The patient underwent canal wall down tympanoplasty elsewhere, and the mastoid cavity is filled with debris. No cholesteatoma is seen in the tympanic cavity. The audiogram shows mild conductive hearing loss with good bone conduction. Ch, cholesteatoma.

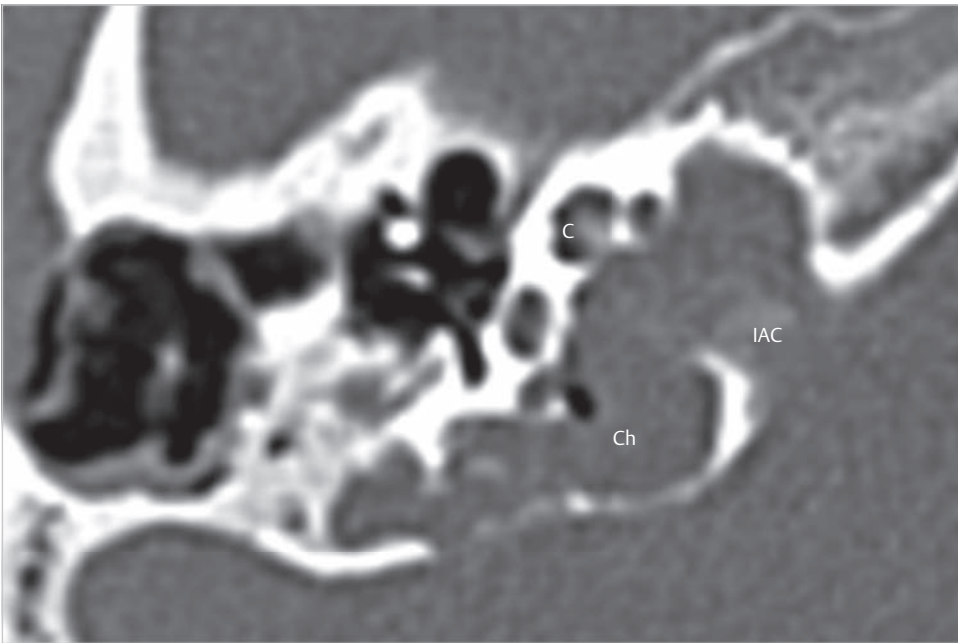


Fig. 14.534 The preoperative axial CT demonstrated that the cholesteatoma has advanced far medially from the partially opened mastoid, eroding the posterior labyrinth, the cochlea, and the internal auditory canal to reach the petrous apex. C, cochlea; Ch, cholesteatoma; IAC, internal auditory canal.

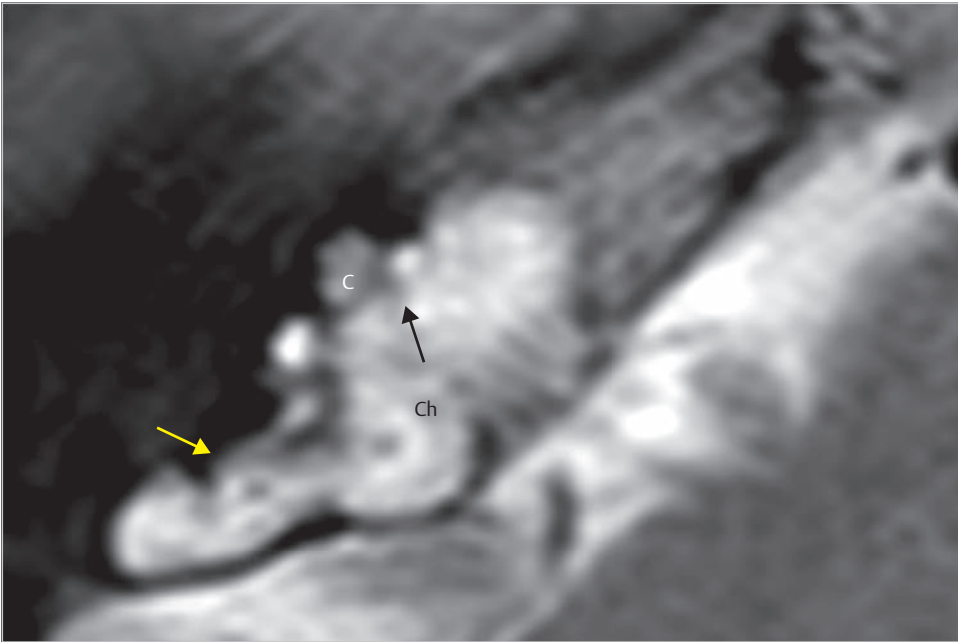


Fig. 14.535 The preoperative MRI demonstrated high signal intensity of the cholesteatoma eroding the posterior semicircular canal (yellow arrow) and the cochlea (black arrow). C, cochlea; Ch, cholesteatoma.

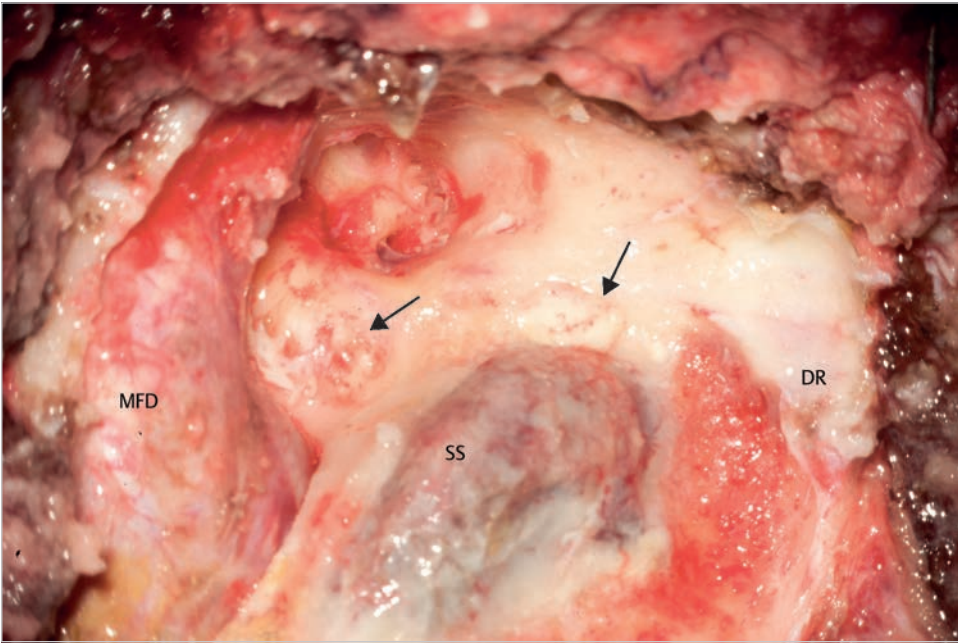


Fig. 14.536 The middle fossa dura is exposed, and the sigmoid sinus is skeletonized at this moment. Note that the bone posterior to the sigmoid sinus is drilled and the mastoid tip is removed to expose the digastric ridge. The posterior meatal wall is removed. The cholesteatoma infiltrating into the petrous apex is started to be seen in the mastoid air cells (arrows). DR, digastric ridge; MFD, middle fossa dura; SS, sigmoid sinus.

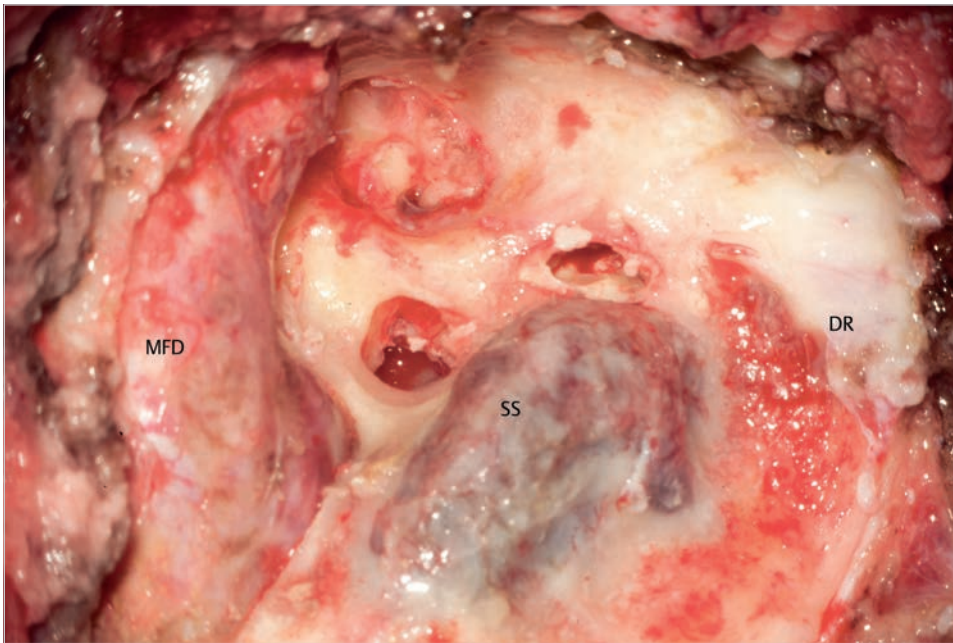


Fig. 14.537 The drilling is advanced medially. The mastoid air cells infiltrated by cholesteatoma are apparent. DR, digastric ridge; MFD, middle fossa dura; SS, sigmoid sinus.

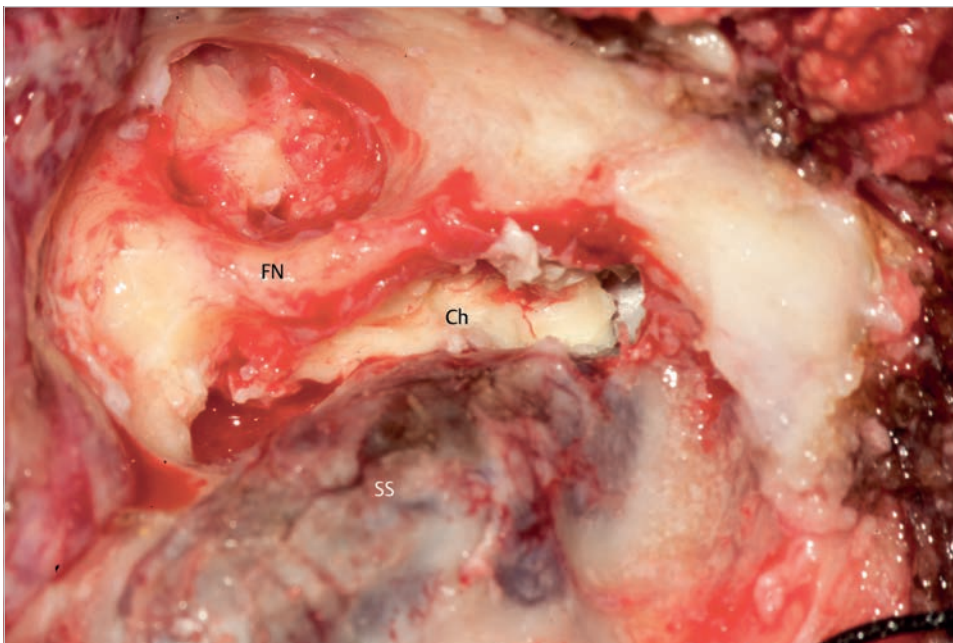


Fig. 14.538 Further removal of the bone exposed huge cholesteatoma located medially to the labyrinth. The sigmoid sinus is exposed to enhance access to the digastric ridge (DR). Ch, cholesteatoma; FN, facial nerve; SS, sigmoid sinus petrous apex.

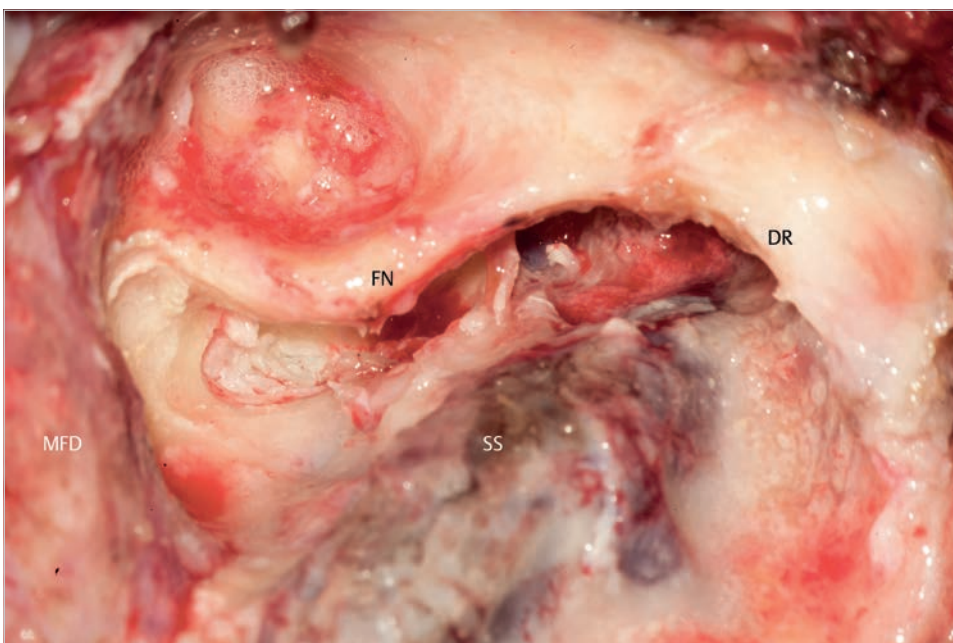


Fig. 14.539 The drilling is advanced superiorly by removing lateral and posterior semicircular canals. Facial nerve is well skeletonized. Note the digastric ridge pointing directly the facial nerve. DR, digastric ridge; FN, facial nerve; MFD, middle fossa dura; SS, sigmoid sinus.

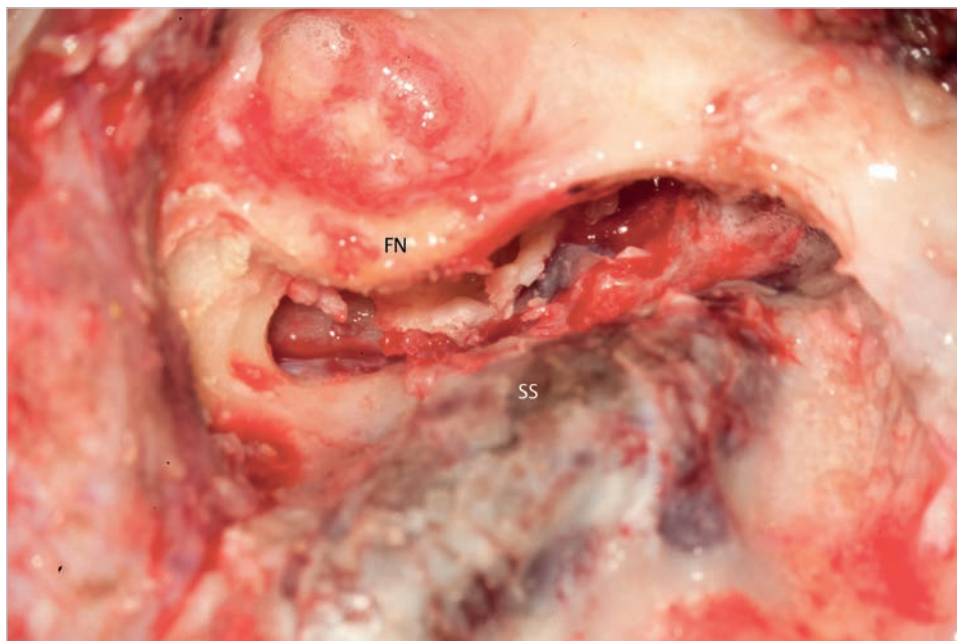


Fig. 14.540 Evacuation of the debris revealed extensive exposure of the posterior fossa dura. FN, facial nerve; SS, sigmoid sinus.

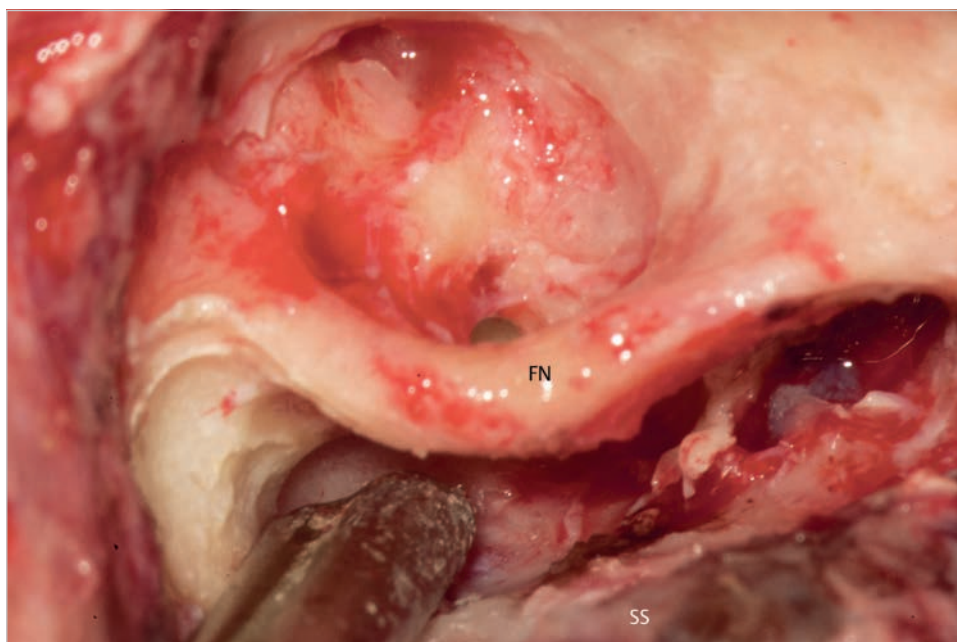


Fig. 14.541 The medial wall of the tympanic cavity is started to be filled to enlarge access to the petrous apex. FN, facial nerve; SS, sigmoid sinus.

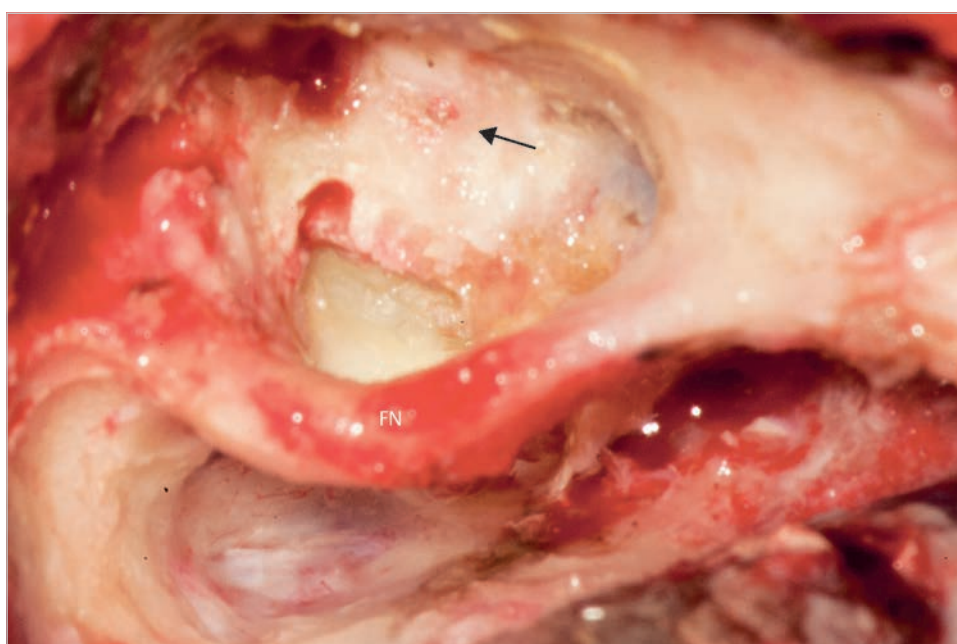


Fig. 14.542 The cochlea is ossified, and the cholesteatoma eroded the cochlea from medial. The arrow indicates the apical turn of the cochlea. For protection of the facial nerve, a thin bony shell should be left over it. FN, facial nerve.

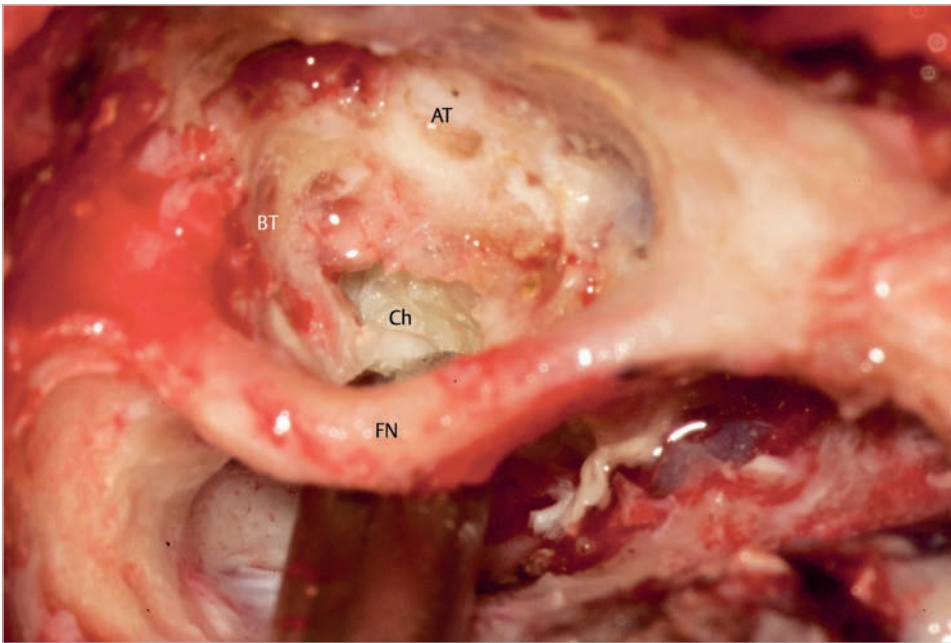


Fig. 14.543 The cholesteatoma infiltrating modiolus is seen. AT, apical turn of cochlea; BT, basal turn of cochlea (upper pole); Ch, cholesteatoma; FN, facial nerve.

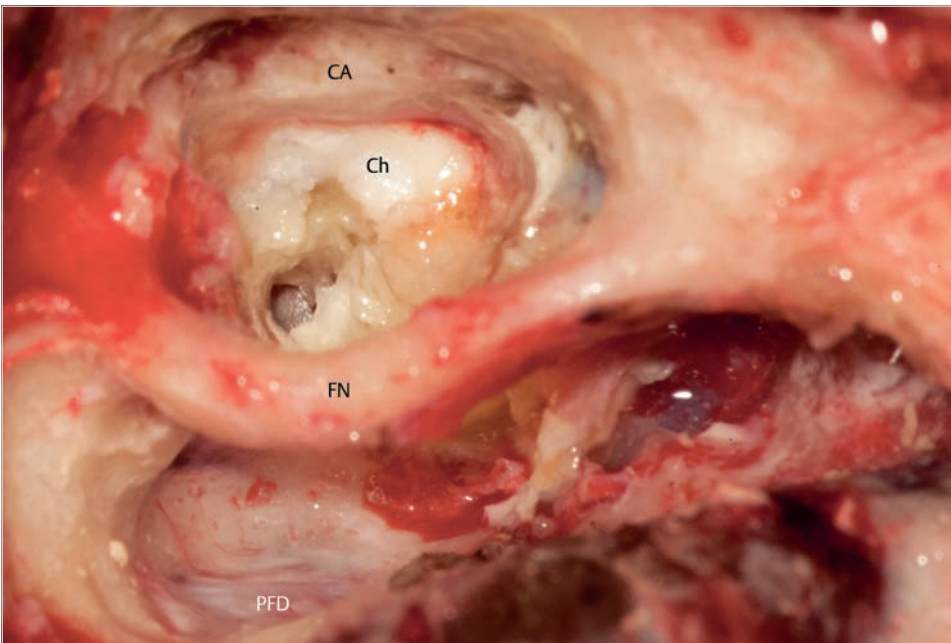


Fig. 14.544 The cholesteatoma located medially to the cochlea is seen. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; PFD, posterior fossa dura.

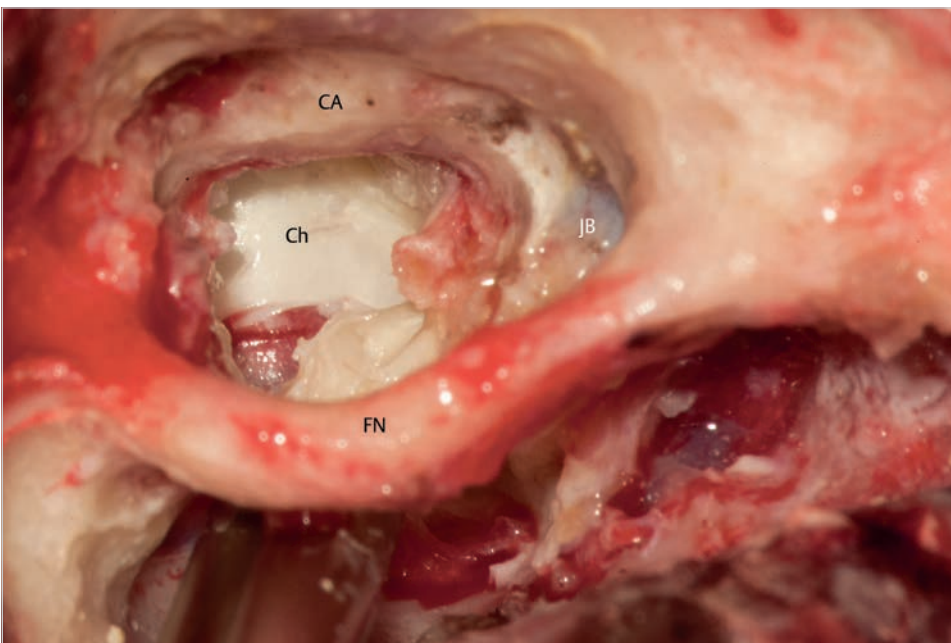


Fig. 14.545 Debris of the cholesteatoma filling the petrous apex is partially evacuated. The position of the jugular bulb located comparatively inferiorly permits access to the petrous apex from the area under the facial nerve. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve; JB, jugular bulb.

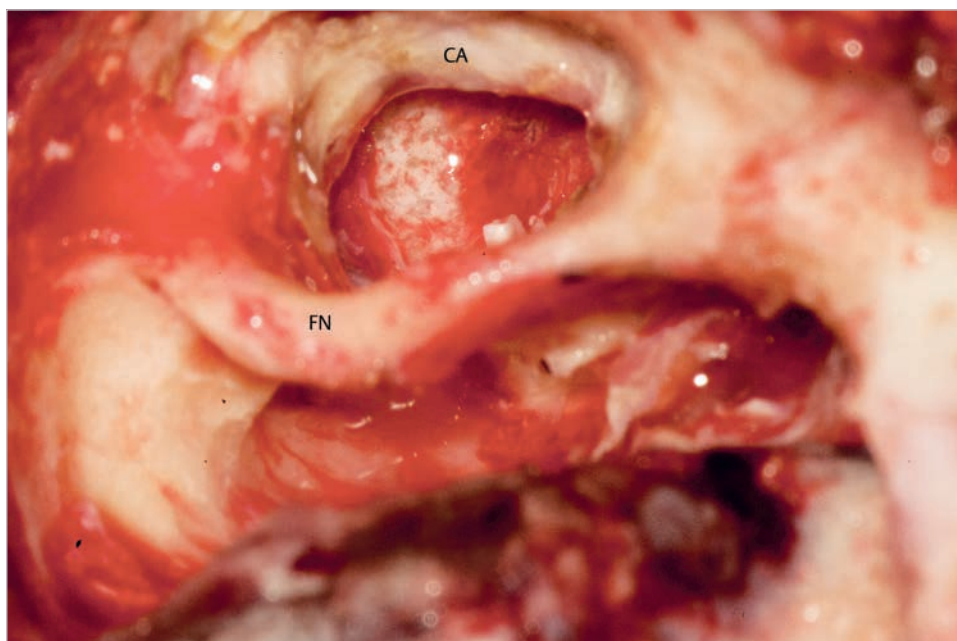


Fig. 14.546 The bone posterosuperiorly to the carotid artery obstructs the view of the superior pole of the cholesteatoma. CA, carotid artery; FN, facial nerve.

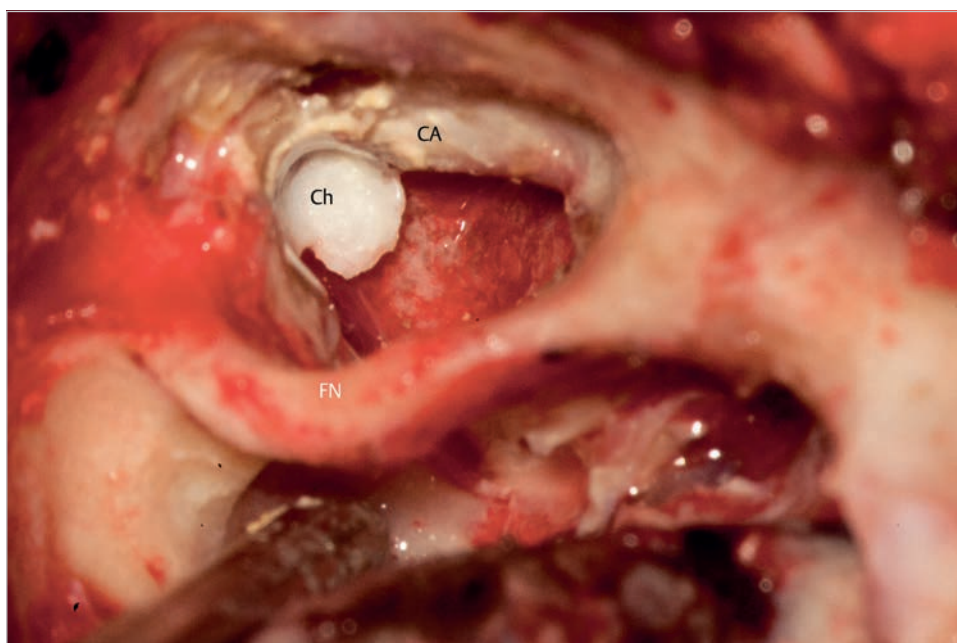


Fig. 14.547 Drilling of the bone posteriorly to the carotid artery exposed the upper pole of the cholesteatoma. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

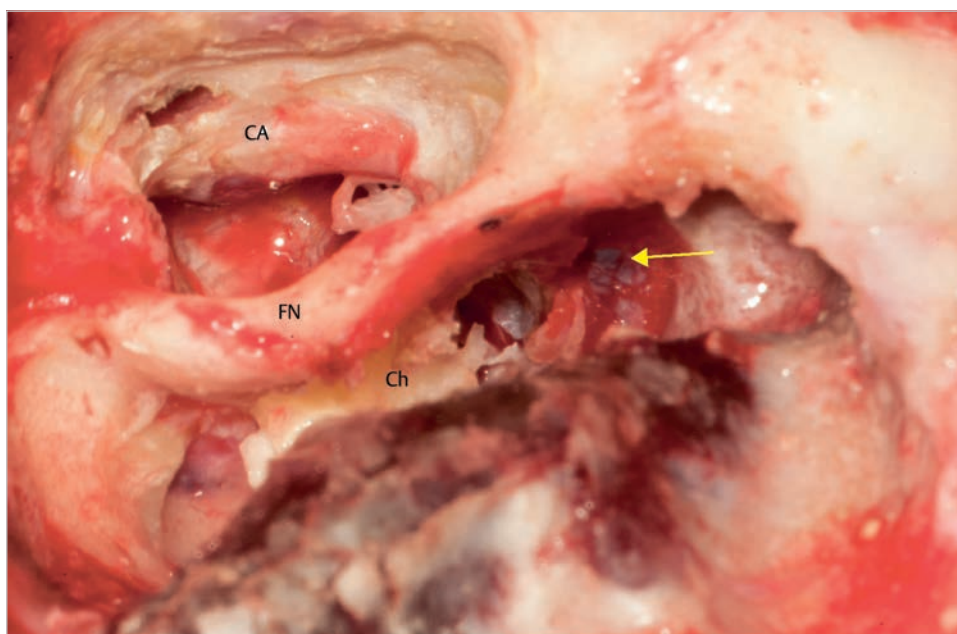


Fig. 14.548 The majority of the cholesteatoma is removed except the area of the jugular bulb (arrow). CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

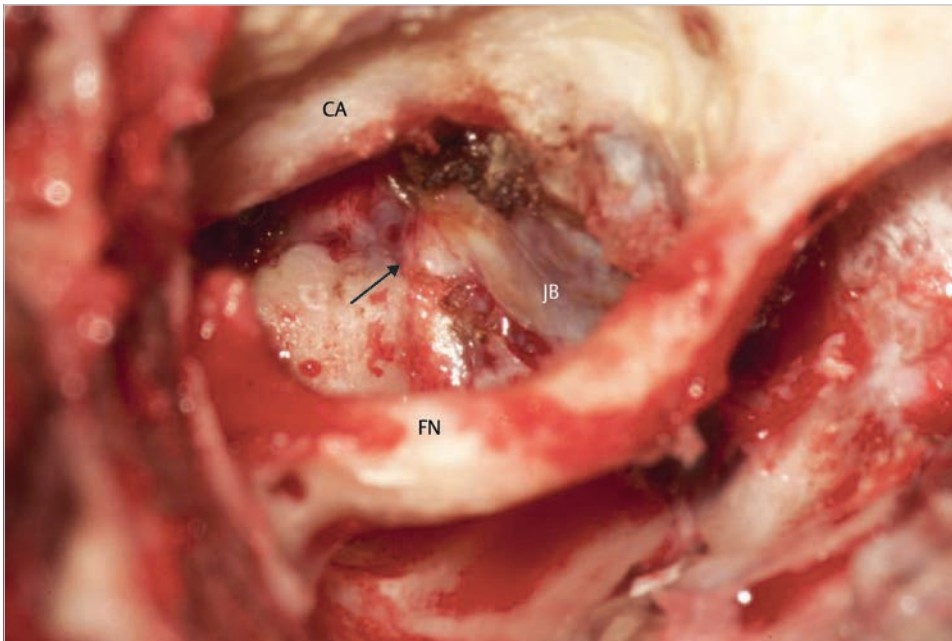


Fig. 14.549 Anteriorly to the jugular bulb, the ninth cranial nerve passing the anterior part of the jugular foramen (pars nervosa) is seen (*arrow*). CA, carotid artery; FN, facial nerve; JB, jugular bulb.

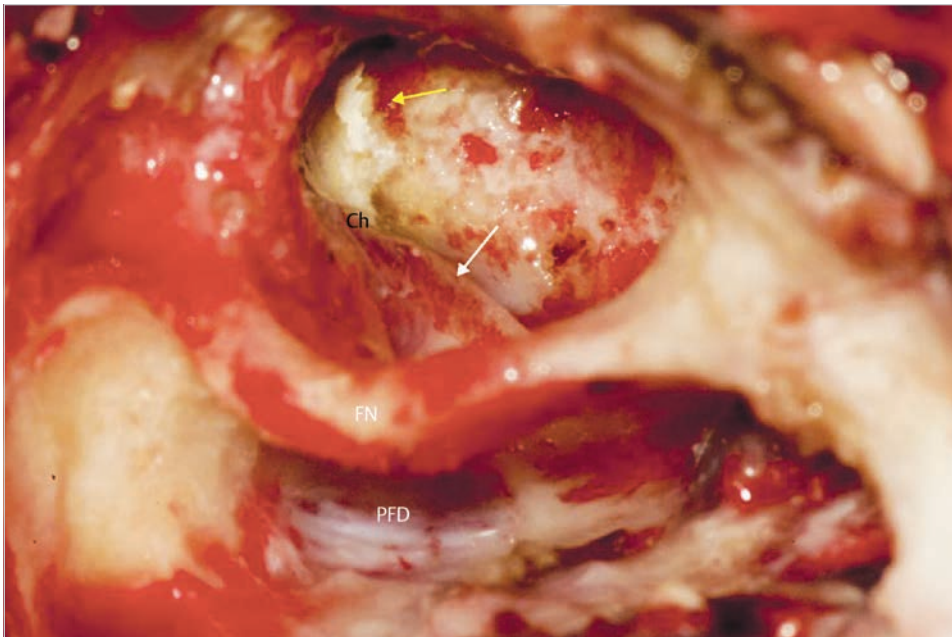


Fig. 14.550 The inferior face of the internal auditory canal is exposed in the cholesteatoma (*white arrow*). Some matrix remains anteriorly to it (*yellow arrow*). Ch, cholesteatoma; FN, facial nerve; PFD, posterior fossa dura.

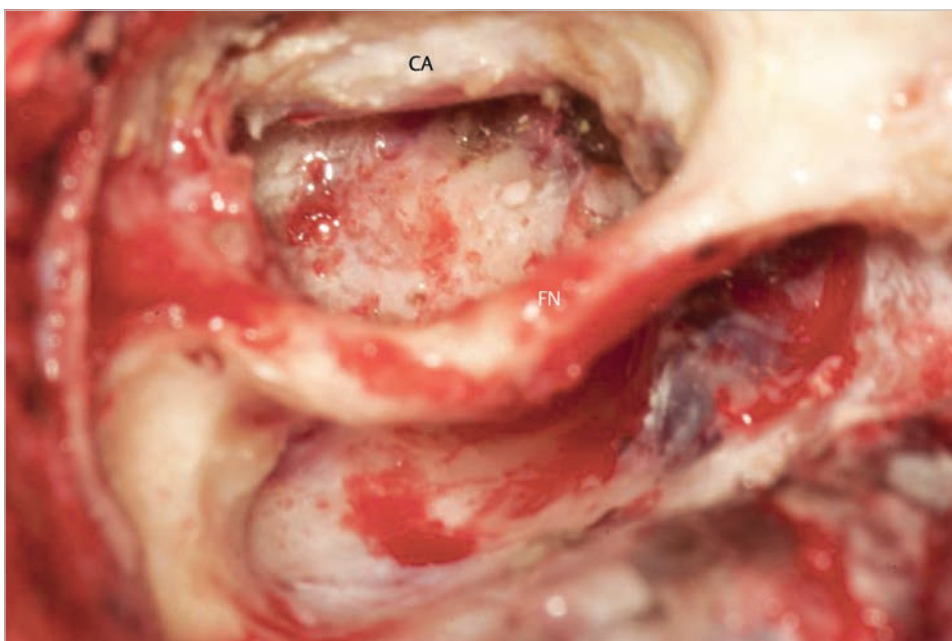


Fig. 14.551 Cleaning of the area anterior to the internal auditory canal is accomplished. CA, carotid artery; FN, facial nerve.

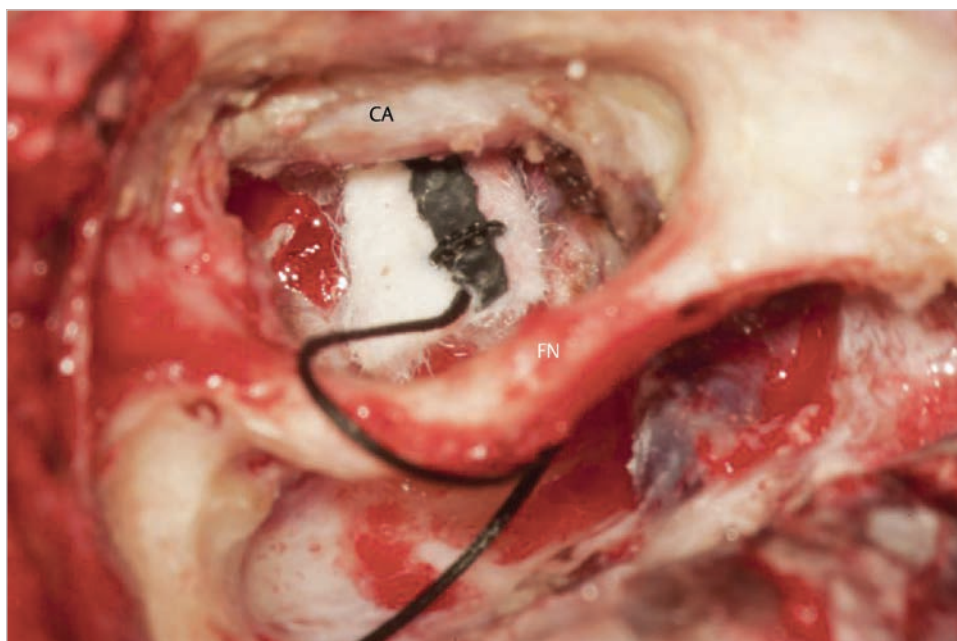


Fig. 14.552 The wall of the petrous apex is scrubbed with cottonoid. CA, carotid artery; FN, facial nerve.

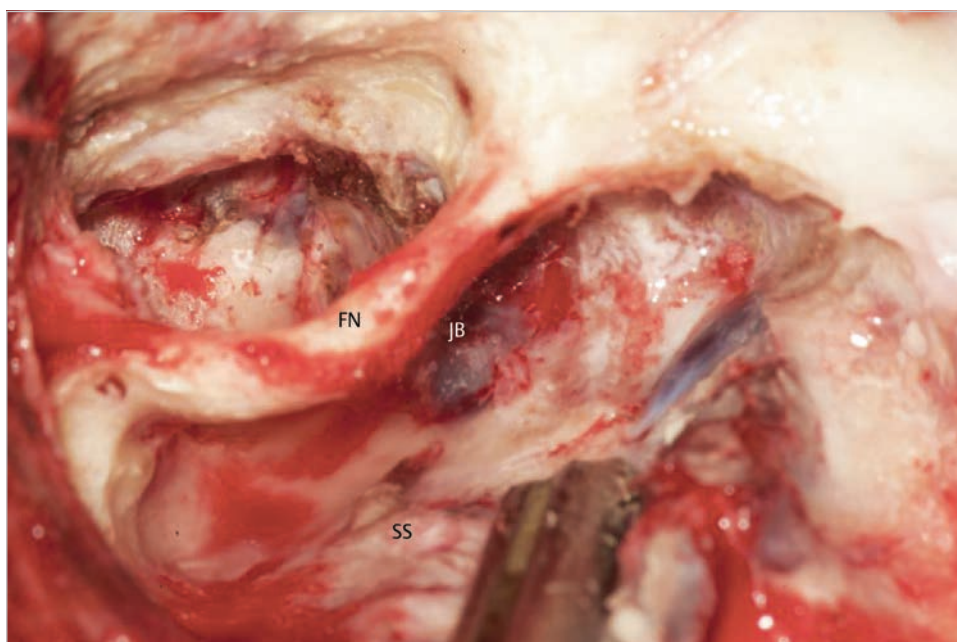


Fig. 14.553 The exposed sigmoid sinus is pushed posteriorly with the suction irrigator to enlarge access to the area of the jugular bulb. FN, facial nerve; JB, jugular bulb; SS, sigmoid sinus.



Fig. 14.554 Enlarged view. The area of the jugular bulb is shown. FN, facial nerve; JB, jugular bulb; SS, sigmoid sinus.



Fig. 14.555 The area with suspicion of removal of skin that occurs occasionally at the border of bone is coagulated. In this case, boundary between the jugular bulb and the bone is coagulated. FN, facial nerve; JB, jugular bulb.

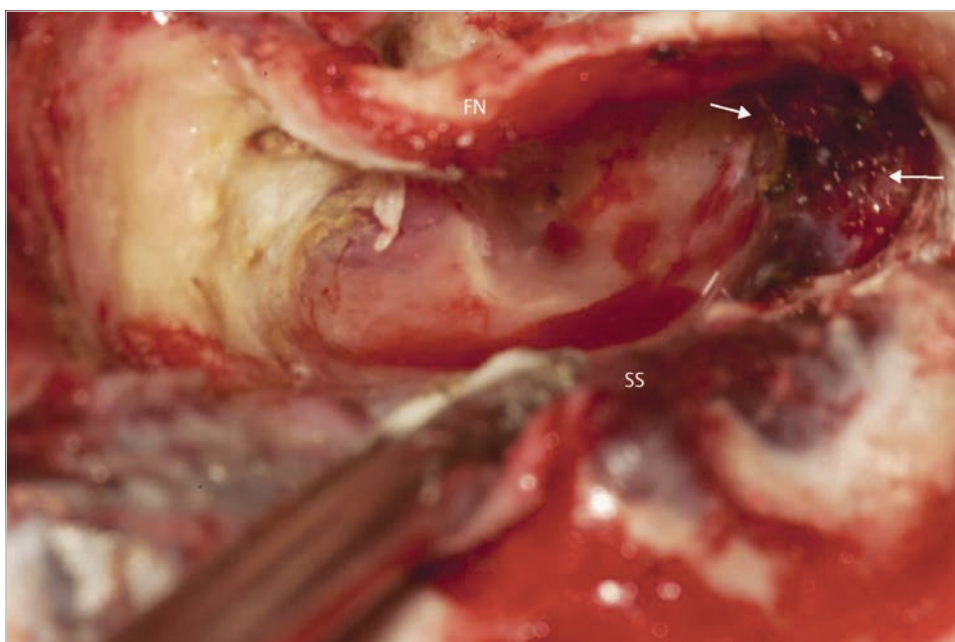


Fig. 14.556 The area is coagulated (*arrows*) not to leave skin behind. FN, facial nerve; SS, sigmoid sinus.

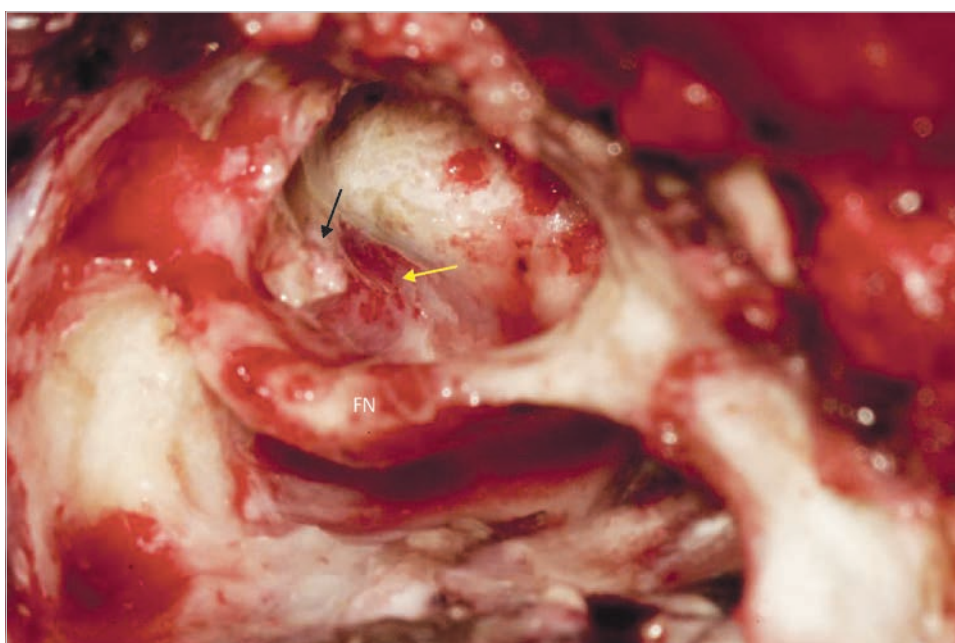


Fig. 14.557 The inferior face of the internal auditory canal is shown. The bone lateral to the exposed dura (*yellow arrow*) of the internal auditory canal corresponds to the fundus of the internal auditory canal (*black arrow*). FN, facial nerve.



Fig. 14.558 The final shape of the petrous apex is shown. CA, carotid artery; CL, clivus; FN, facial nerve; JB, jugular bulb.

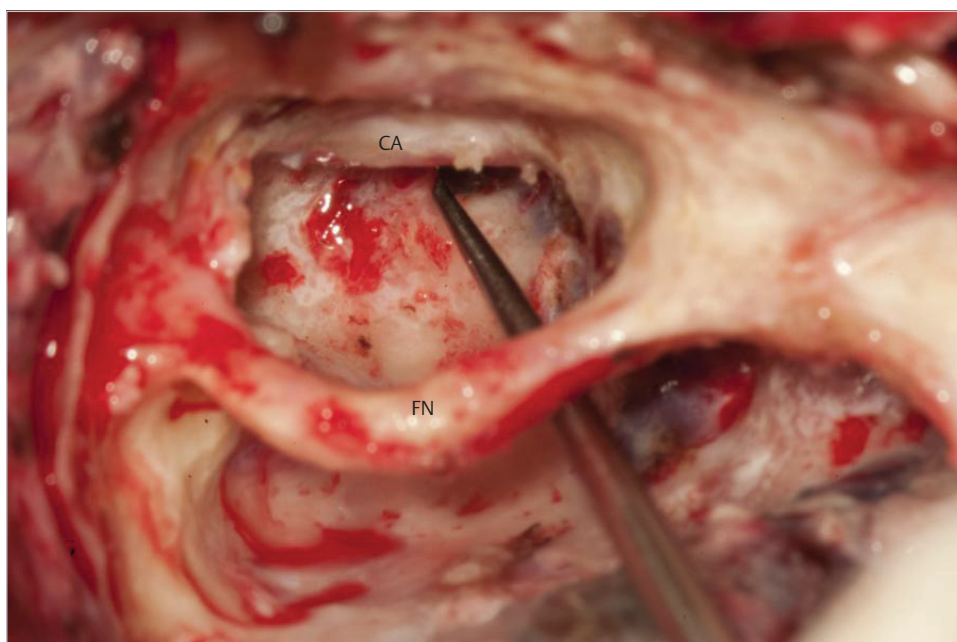


Fig. 14.559 There is suspicious area of total removal under the carotid artery. CA, carotid artery; FN, facial nerve.

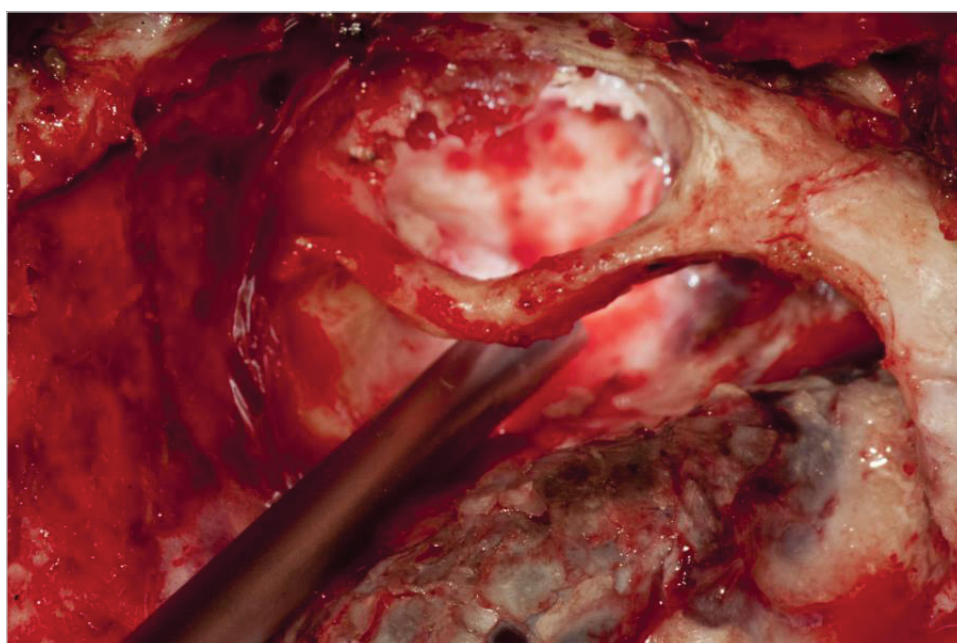


Fig. 14.560 The area suspicious of complete removal of the skin is checked with an endoscope.

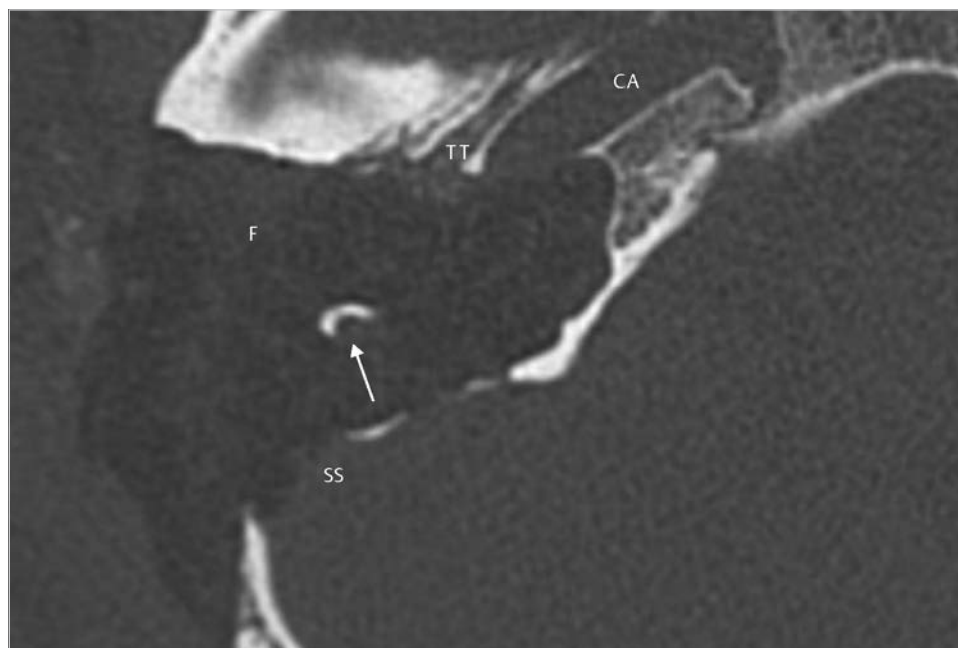


Fig. 14.561 Postoperative CT shows extensive removal of bone from the petrous apex. The mastoid segment of the facial nerve is left in the fallopian canal (*arrow*). The posterior fossa dura is partially exposed, and the carotid artery is uncovered posterolaterally. CA, carotid artery; F, abdominal fat; SS, sigmoid sinus; TT, tensor tympani.

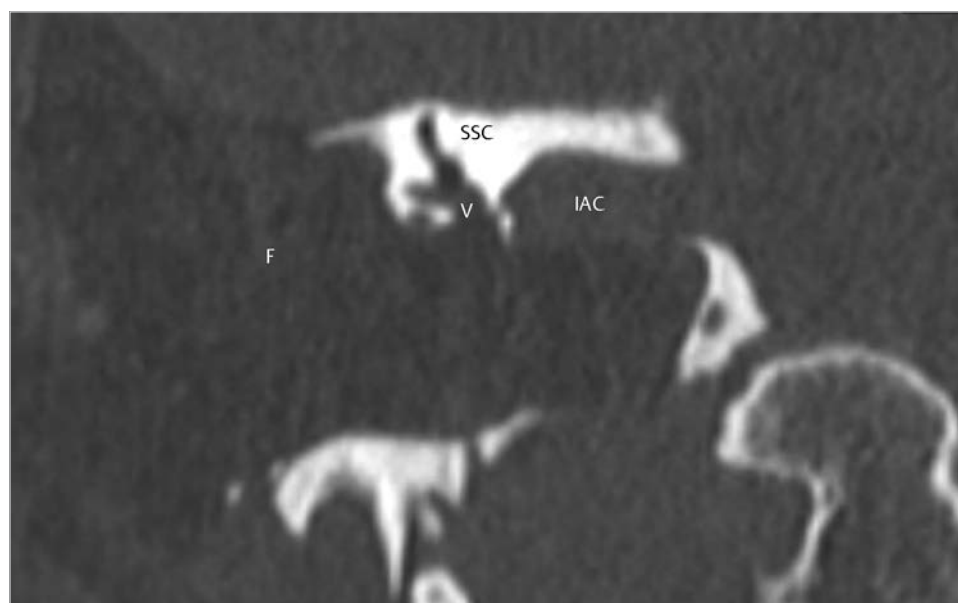


Fig. 14.562 The coronal section shows exposure of the inferior face of the internal auditory canal. Even though the majority of the inner ear was removed, the most anterior part of the posterior labyrinth is seen in this section. F, abdominal fat; IAC, internal auditory canal; SSC, superior semicircular canal; V, vestibule.

Case 14.24 (Left Ear)

See ▶ Fig. 14.563, ▶ Fig. 14.564, ▶ Fig. 14.565, ▶ Fig. 14.566, ▶ Fig. 14.567, ▶ Fig. 14.568, ▶ Fig. 14.569, ▶ Fig. 14.570, ▶ Fig. 14.571, ▶ Fig. 14.572, ▶ Fig. 14.573, ▶ Fig. 14.574, ▶ Fig. 14.575, ▶ Fig. 14.576, ▶ Fig. 14.577, ▶ Fig. 14.578, ▶ Fig. 14.579, ▶ Fig. 14.580, ▶ Fig. 14.581, ▶ Fig. 14.582.

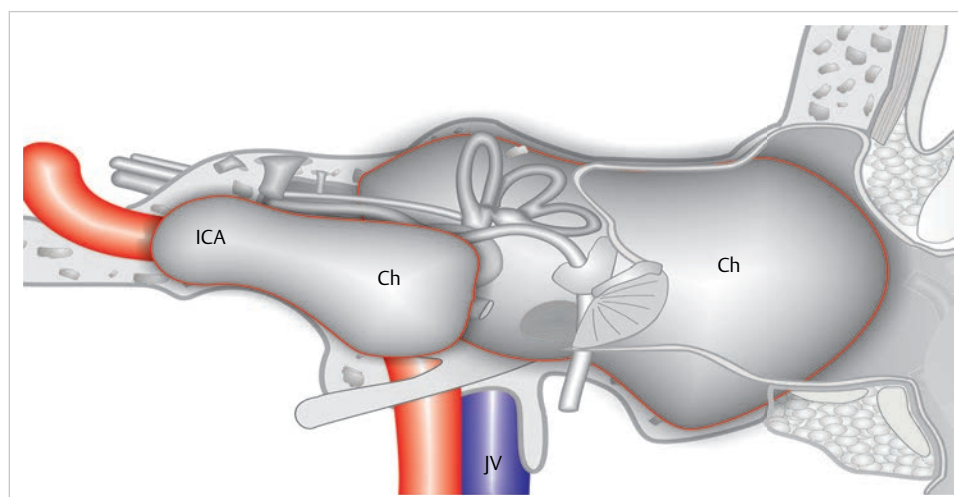


Fig. 14.563 A case of massive petrous bone cholesteatoma arose in canal wall down cavity. The otic capsule is completely destroyed, and cholesteatoma infiltrates the area anteriorly to the horizontal segment of the internal carotid artery. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

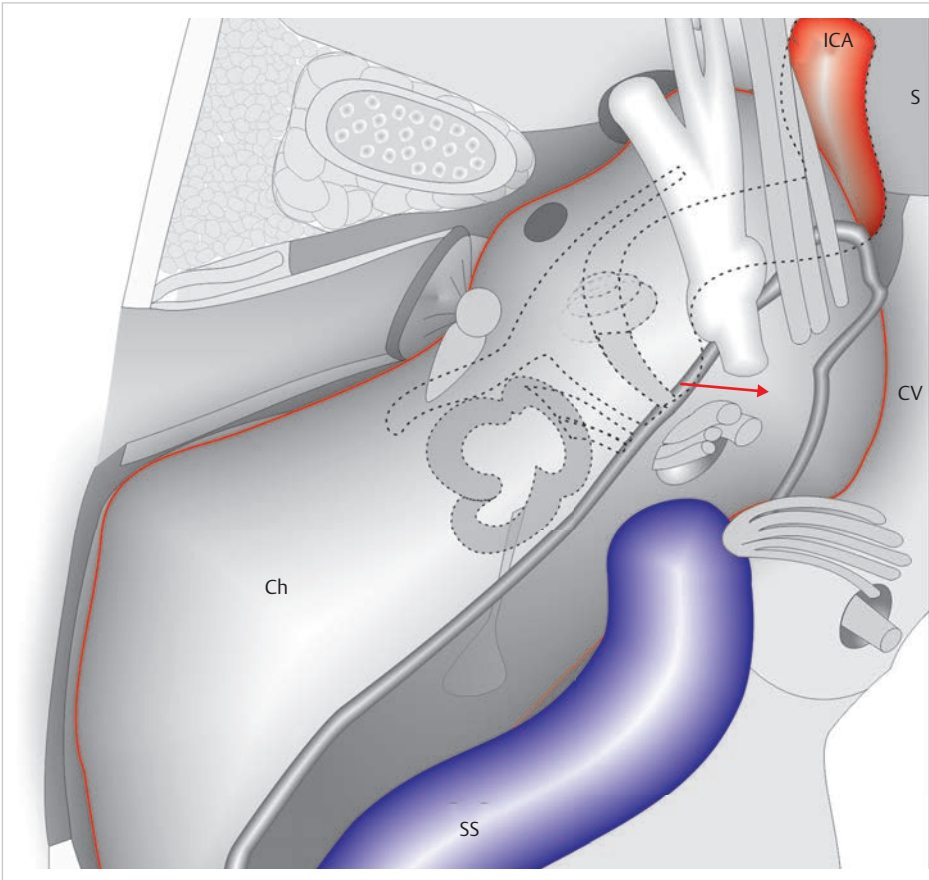


Fig. 14.564 The cholesteatoma went deep to erode the clivus (*arrow*). To control the horizontal segment of the internal carotid artery, modified transcochlear approach combined with infratemporal fossa approach type B is indicated. Ch, cholesteatoma; CV, clivus; ICA, internal carotid artery; S, sphenoid sinus; SS, sigmoid sinus.

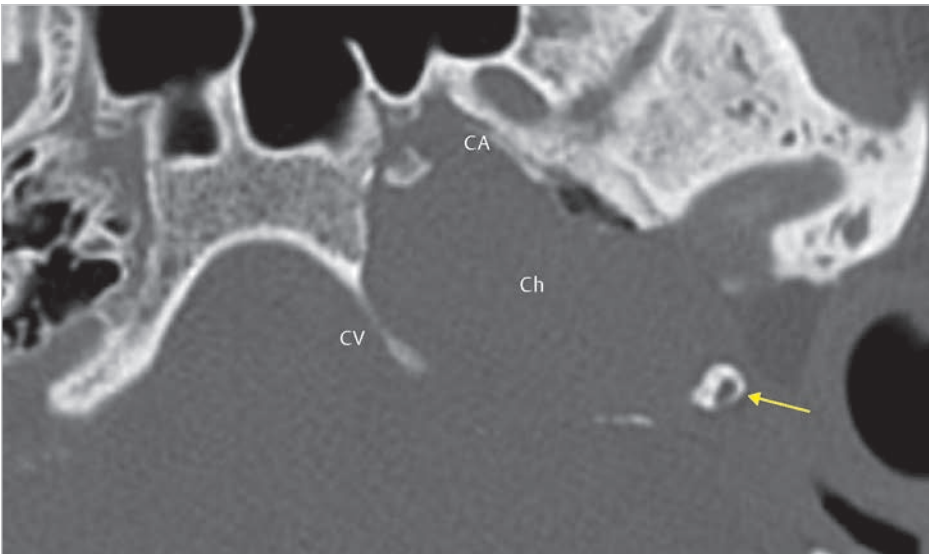


Fig. 14.565 The patient underwent surgery four times elsewhere including middle fossa approach with no radical removal of cholesteatoma. The axial CT demonstrates presence of a massive round-shaped mass in the petrous apex. The majority of structures in the temporal bone is disappeared except the fallopian canal (*arrow*). CA, carotid artery; Ch, cholesteatoma; CV, clivus.

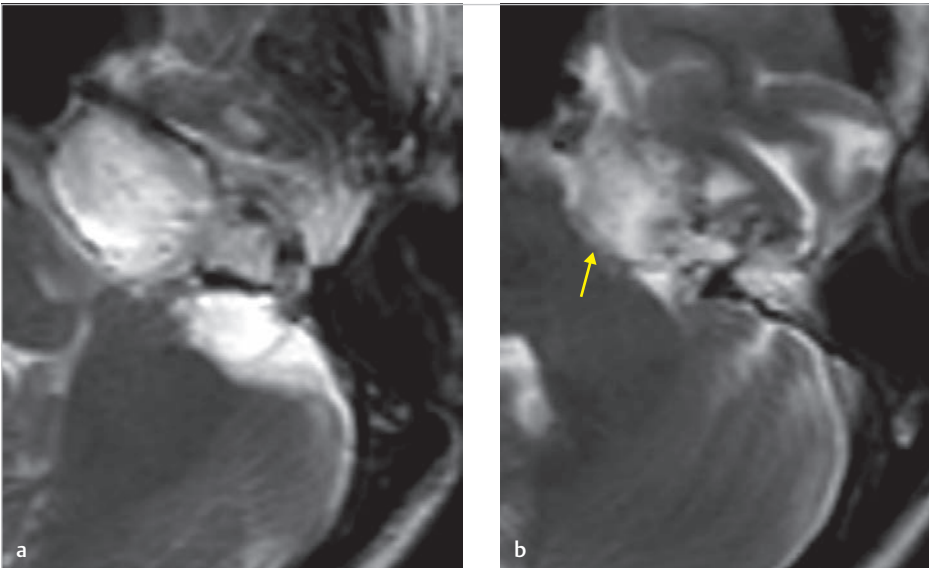


Fig. 14.566 The axial image of T2-weighted MRI (**a**) shows a massive high-signal lesion corresponding to cholesteatoma. The MRI, more cranial slice (**b**), shows that the cholesteatoma protrudes to the CP angle, starting to push the brain stem (*arrow*).

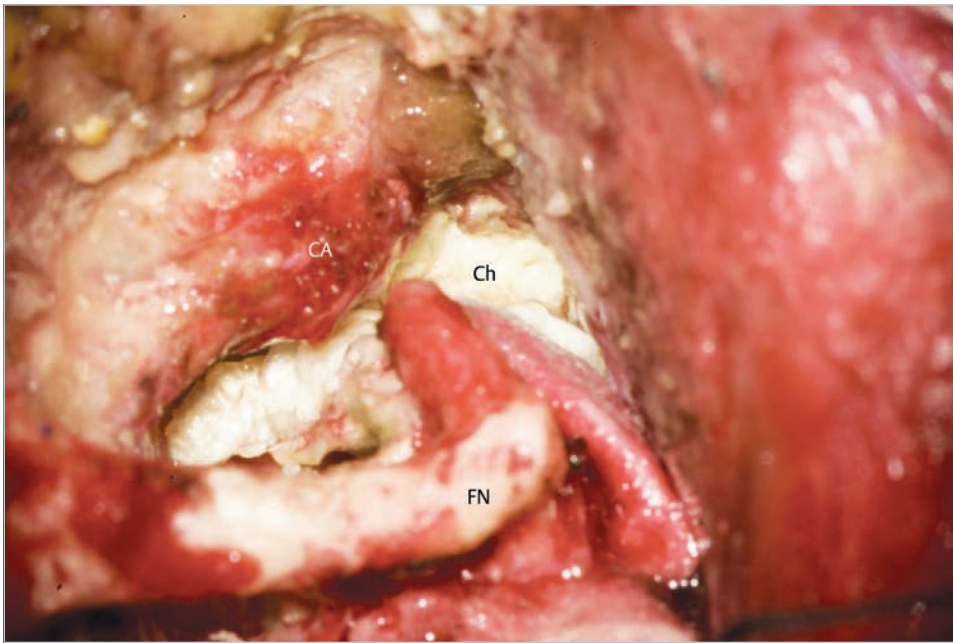


Fig. 14.567 Transotic approach including labyrinthectomy and removal of the cochlea has been completed. The facial nerve is well skeletonized. The greater superficial petrosal nerve is sacrificed. The carotid artery is also skeletonized. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

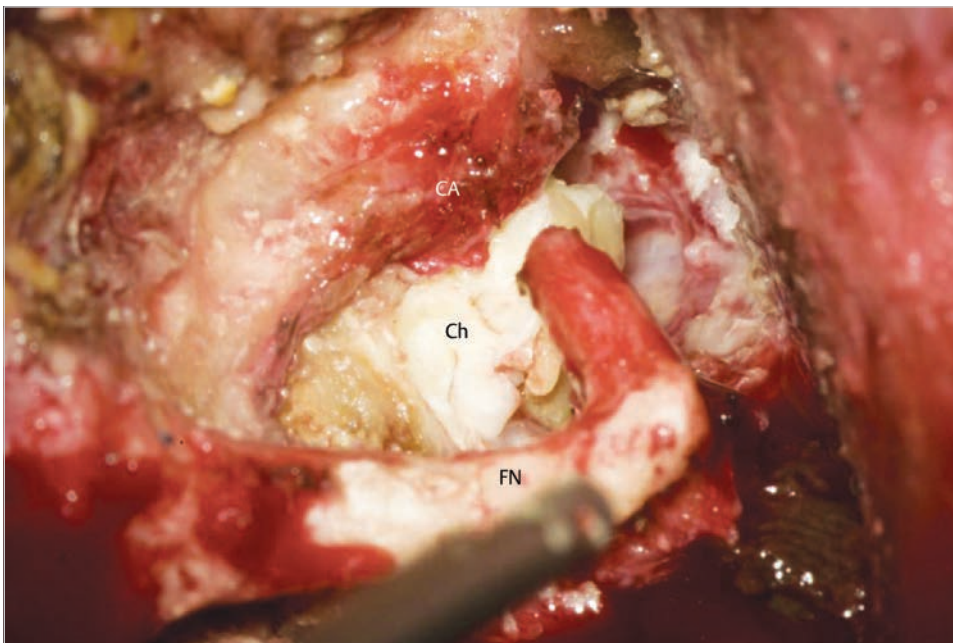


Fig. 14.568 Both the middle and posterior fossa dura is uncovered by the cholesteatoma. The matrix covering the middle fossa dura and the posterior fossa dura is dissected medially. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

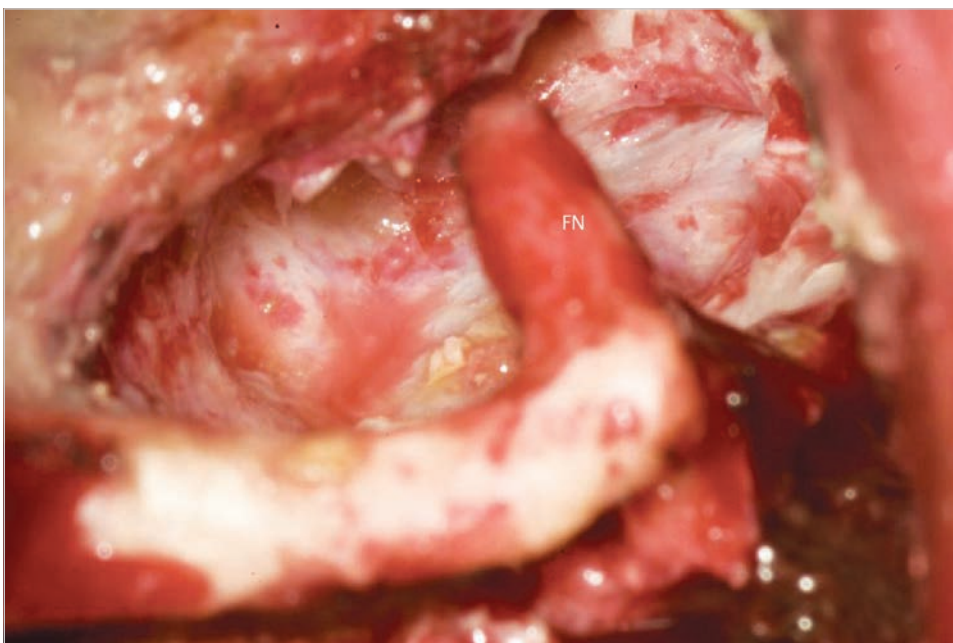


Fig. 14.569 The cholesteatoma is removed from the posterior fossa dura. FN, Facial nerve.

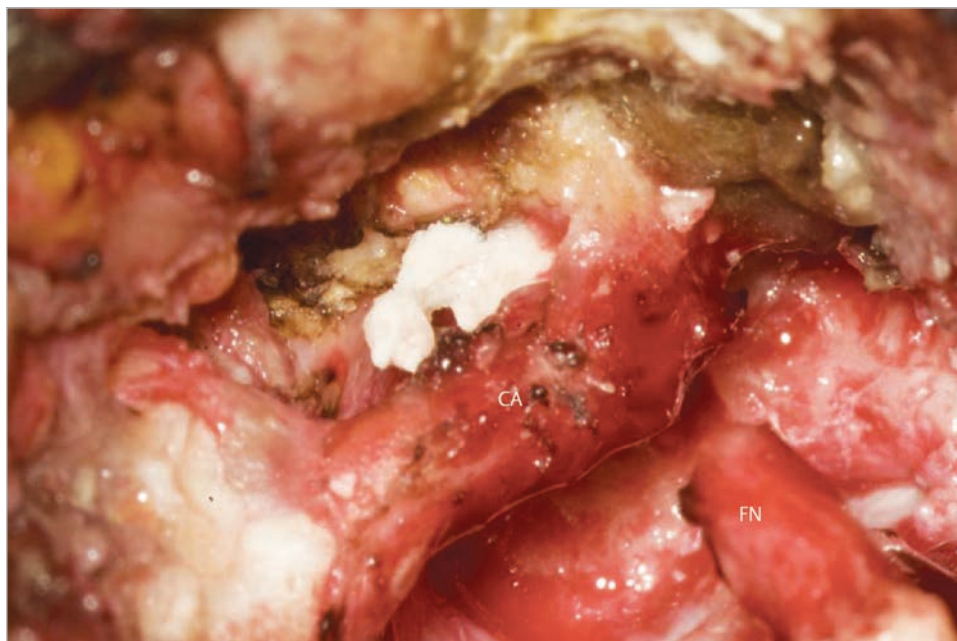


Fig. 14.570 Removal of bone anterior to the carotid artery considerably expands access to the petrous apex. The matrix covering the lateral wall of the petrous apex is removed from this window. FN, facial nerve; CA, carotid artery.

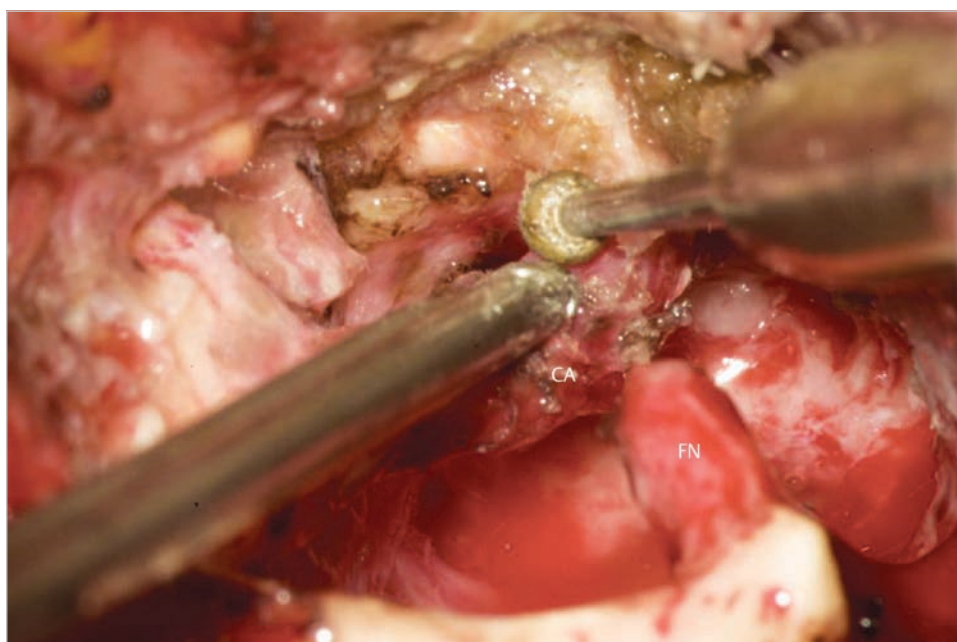


Fig. 14.571 The skeletonization of the carotid artery can be carried out safely with large diamond burs. CA, carotid artery; FN, facial nerve.

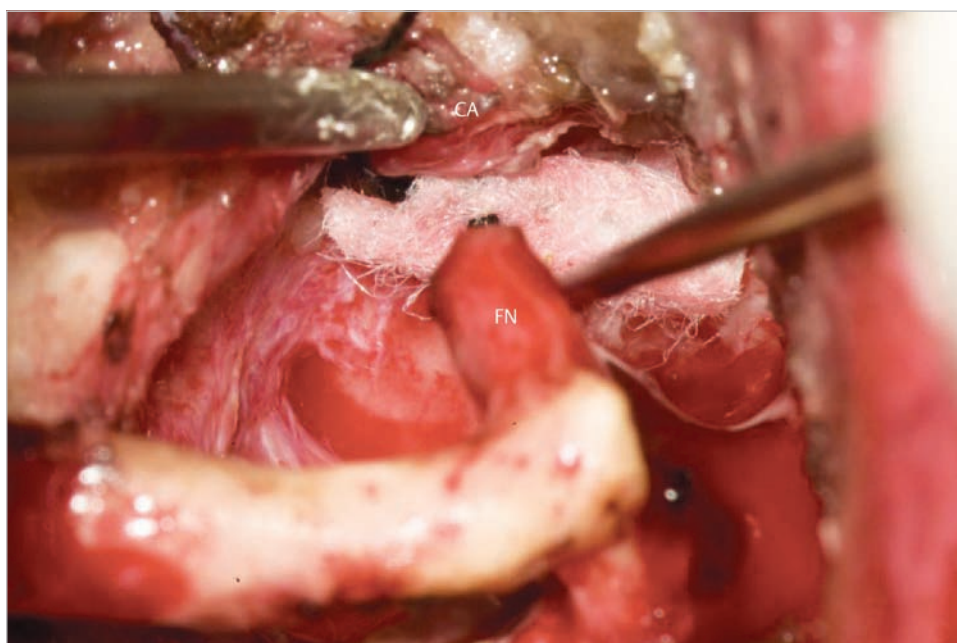


Fig. 14.572 To reduce possibility to leave cholesteatoma matrix on the bony wall, a piece of cottonoid is used to scrub the bony wall and invisible places such as medial face of carotid artery and the facial nerve, and the anterior face of the internal auditory canal. CA, carotid artery; FN, facial nerve.

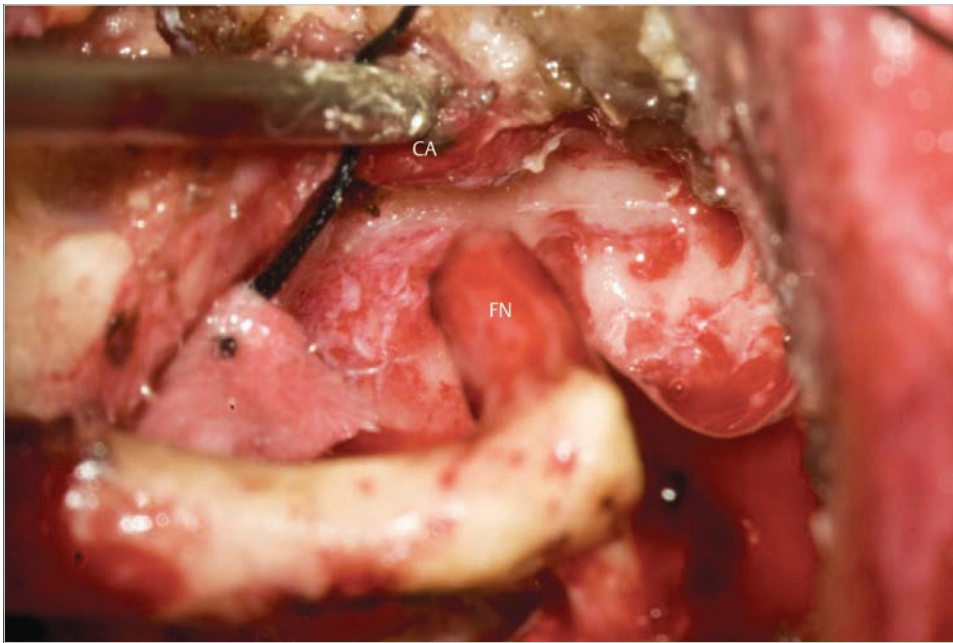


Fig. 14.573 The bony protrusion anterior to the facial nerve covering the carotid artery obstructs some view to the petrous apex. CA, carotid artery; FN, facial nerve.

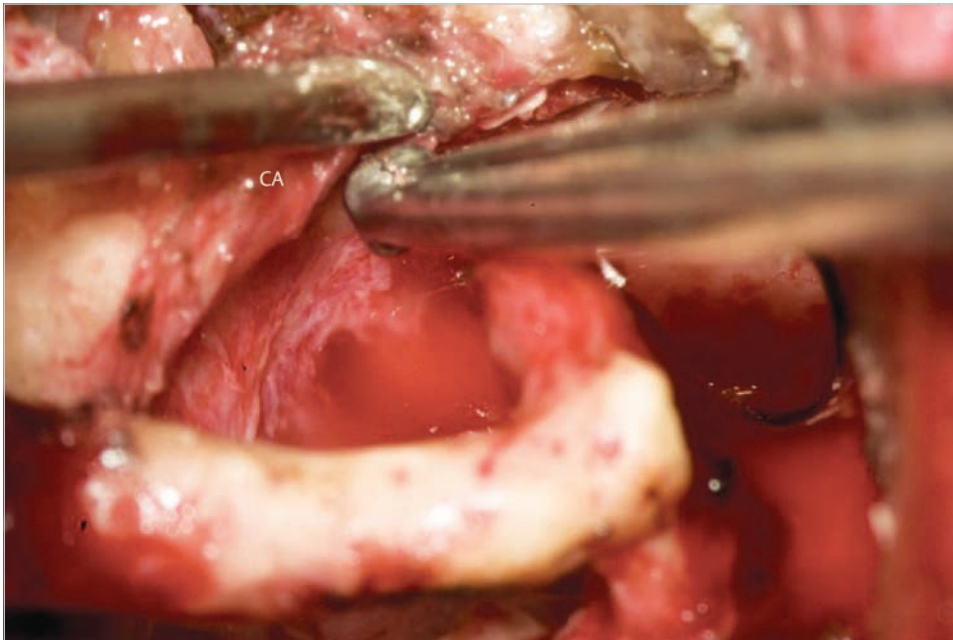


Fig. 14.574 The bone over the posterosuperior wall of the carotid artery can be removed safely with a curette. CA, carotid artery.

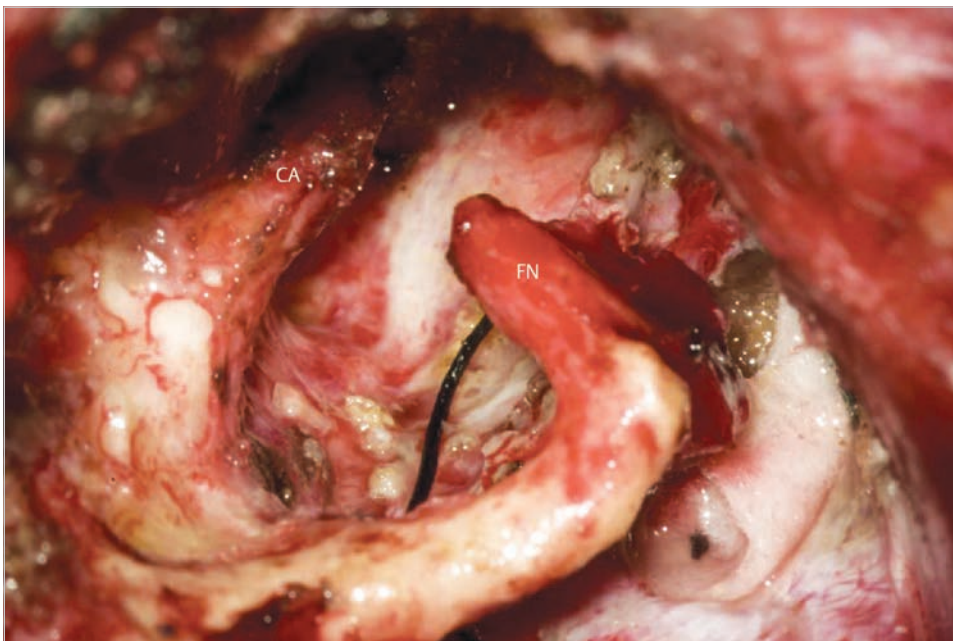


Fig. 14.575 The access to the bottom of the petrous apex becomes better. CA, carotid artery; FN, facial nerve.

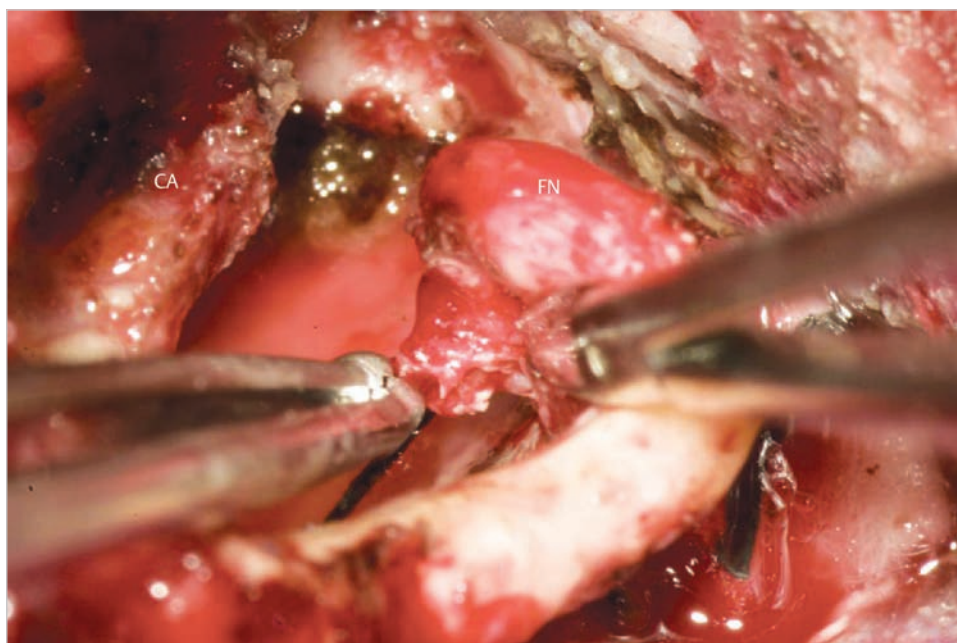


Fig. 14.576 Sharp dissection using scissors is carried out to remove the last piece of cholesteatoma adherent to the inferior face of the internal auditory canal. CA, carotid artery; FN, facial nerve.

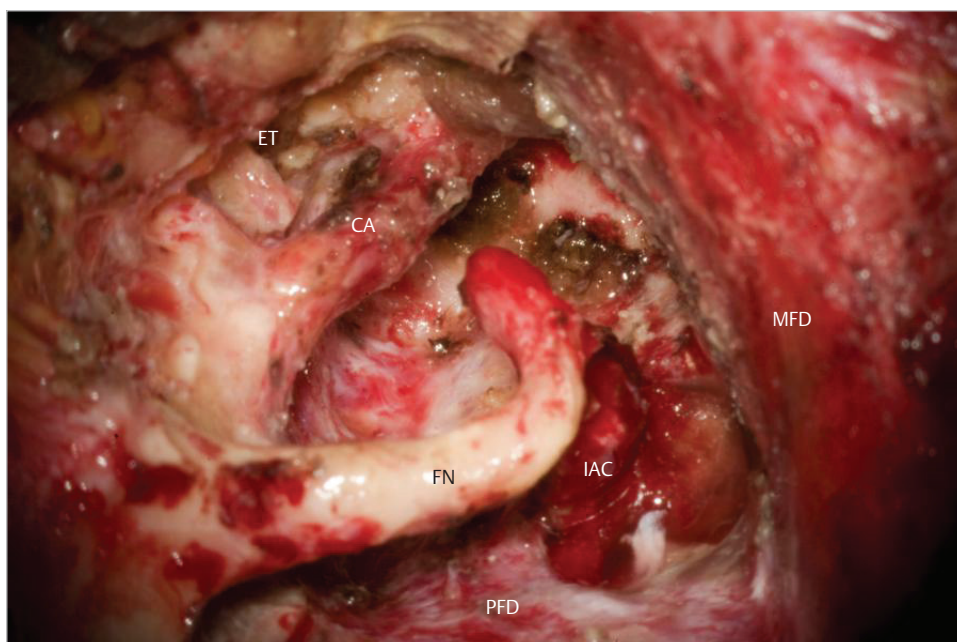


Fig. 14.577 The cholesteatoma is eradicated from the temporal bone. CA, carotid artery; ET, eustachian tube; FN, facial nerve; IAC, internal auditory canal; MFD, middle fossa dura; PFD, posterior fossa dura.

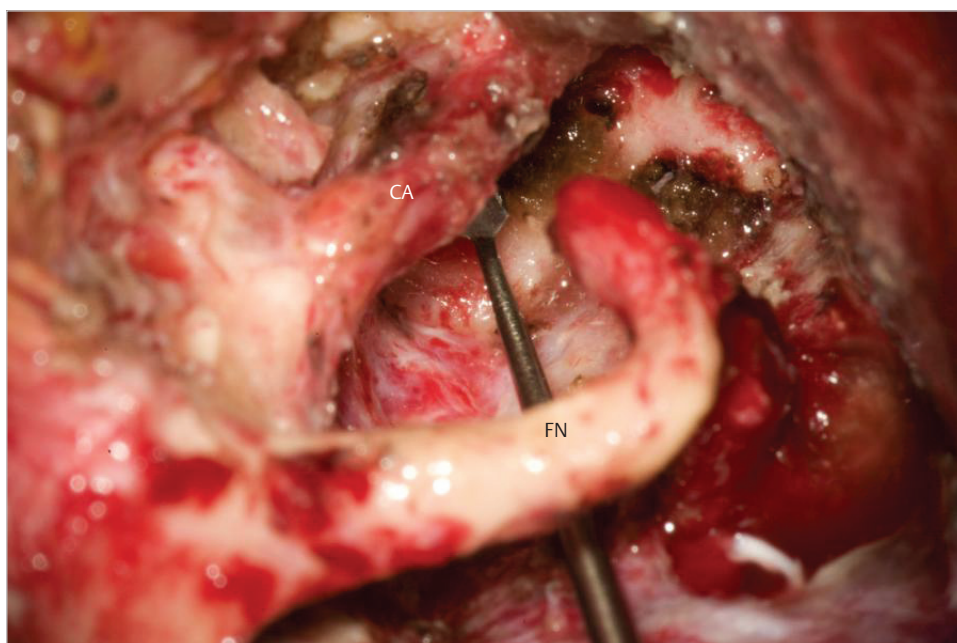


Fig. 14.578 Since the jugular bulb is low in this case, a large space was created under the facial nerve without difficulty. CA, carotid artery; FN, facial nerve.

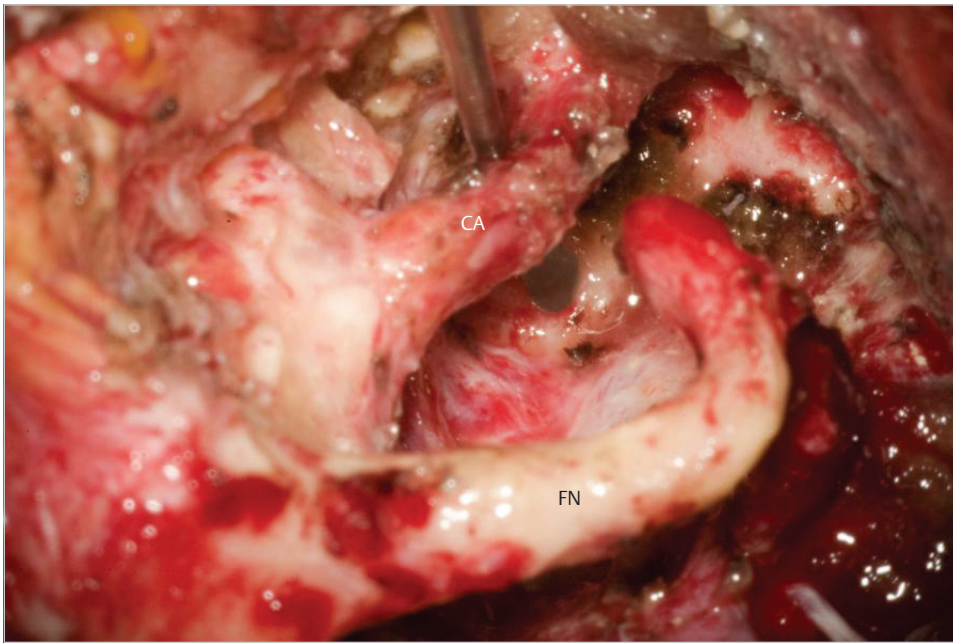


Fig. 14.579 The space created anteriorly to the carotid artery is shown. CA, carotid artery; FN, facial nerve.

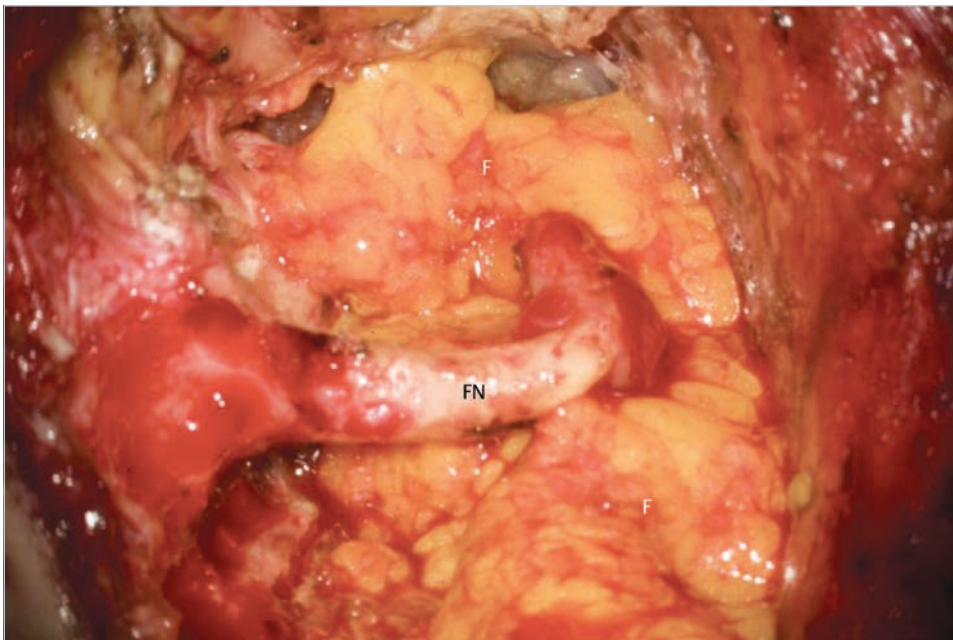


Fig. 14.580 After obliterating the eustachian tube with periosteum, the cavity is packed with abdominal fat. F, abdominal fat; FN, facial nerve.

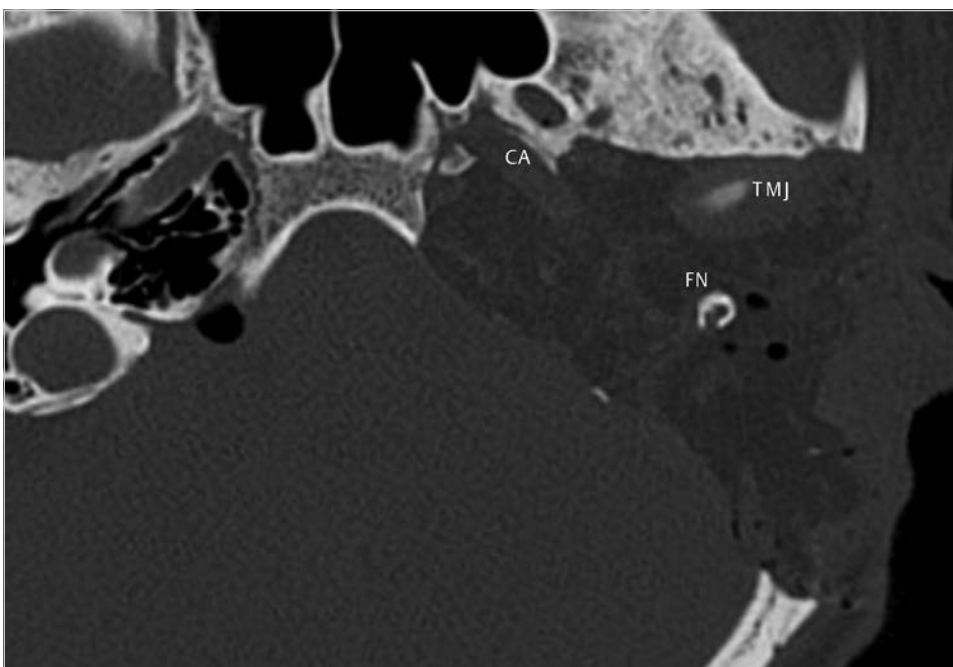


Fig. 14.581 The postoperative CT shows extensive removal of bone from the temporal bone. The axial section demonstrates carotid artery, temporomandibular joint, and the facial nerve in the fallopian canal in the abdominal fat. Note that the drilling reached the area close to the sphenoid sinus. CA, carotid artery; FN, facial nerve; TMJ, temporomandibular joint.

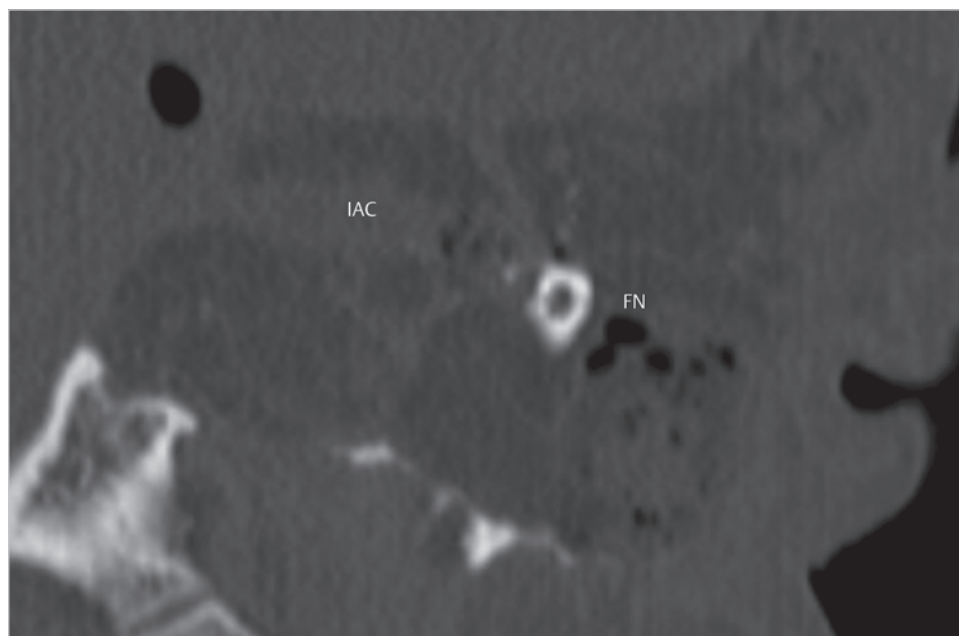


Fig. 14.582 In this coronal section, exposed internal auditory canal is identified. The tympanic segment of the facial nerve runs in the fallopian canal. Note that middle fossa dura and the posterior fossa dura are totally exposed to gain maximum access to the petrous apex. IAC, internal auditory canal; FN, facial nerve.

Case 14.25 (Bilateral)

See ▶Fig. 14.583, ▶Fig. 14.584, ▶Fig. 14.585, ▶Fig. 14.586, ▶Fig. 14.587, ▶Fig. 14.588, ▶Fig. 14.589, ▶Fig. 14.590, ▶Fig. 14.591, ▶Fig. 14.592, ▶Fig. 14.593, ▶Fig. 14.594, ▶Fig. 14.595,

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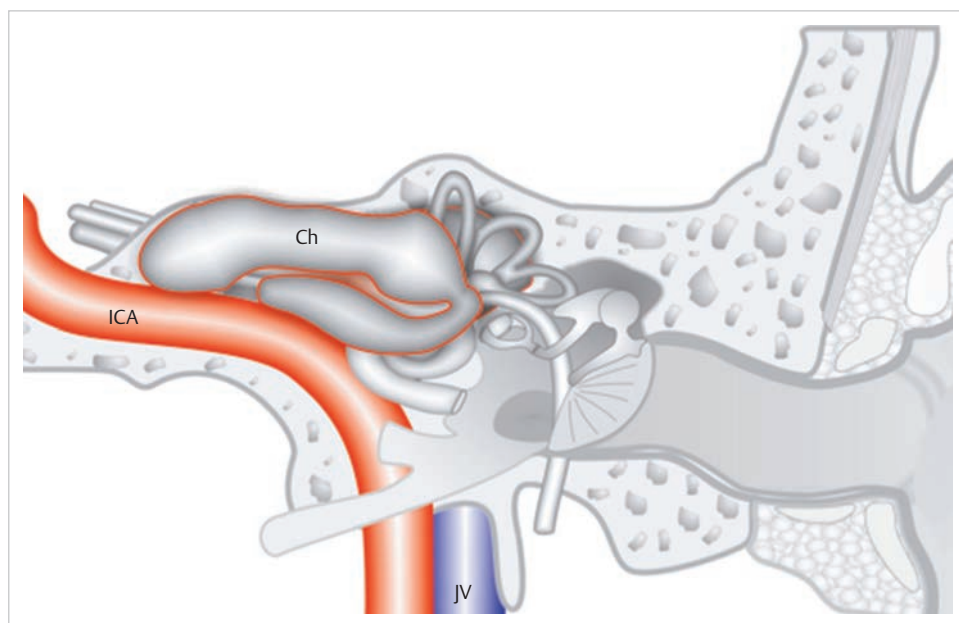


Fig. 14.583 Left ear. A case of bilateral congenital petrous bone cholesteatoma with massive type in the left ear and supralabyrinthine type in the right. The dead left ear is operated first with modified transcochlear approach. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.



Fig. 14.584 The patient was referred for presence of petrous bone cholesteatoma in both ear. The patient suffered from progressive left hearing loss and ipsilateral facial palsy started from 2 years before. The hearing loss and palsy fell into dead ear and completed at presentation. The otoscopy shows only a small abnormality, a shallow dimple in the anterosuperior quadrant of the left (b).

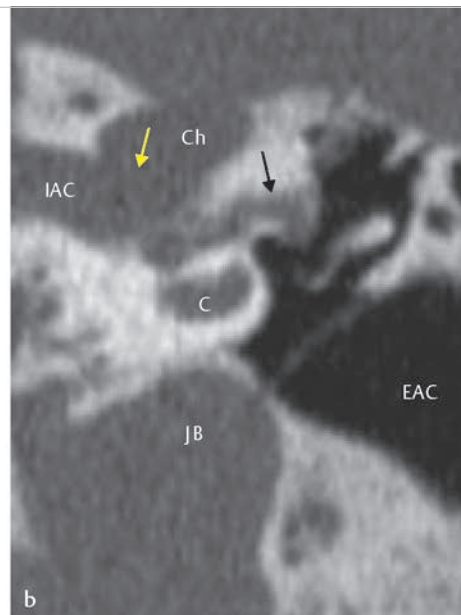
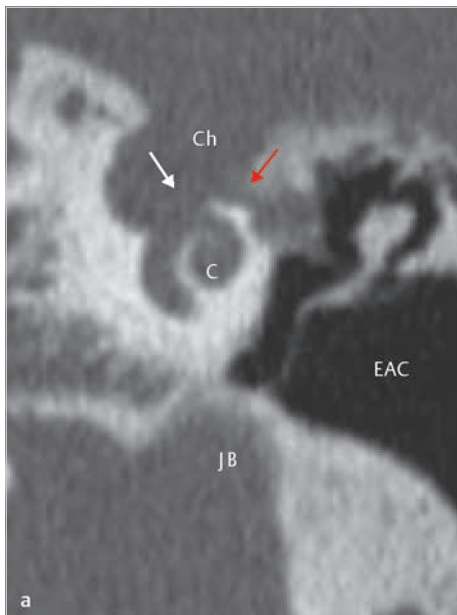


Fig. 14.585 The coronal CT images at the level of the apical turn of the cochlea (a) and the area just anterior to the footplate (b) demonstrate presence of cholesteatoma infiltrating the cochlea (white arrow) and the internal auditory canal (yellow arrow). The fallopian canal is also infiltrated in the labyrinthine segment (red arrow) and the tympanic segment (black arrow). The rough surface of the bone in the medial wall of attic is suggestive of bone erosion. A very large, anteriorly located jugular bulb is seen in the floor of the tympanic cavity. C, cochlea; Ch, cholesteatoma; EAC, external auditory canal; IAC, internal auditory canal; JB, jugular bulb.

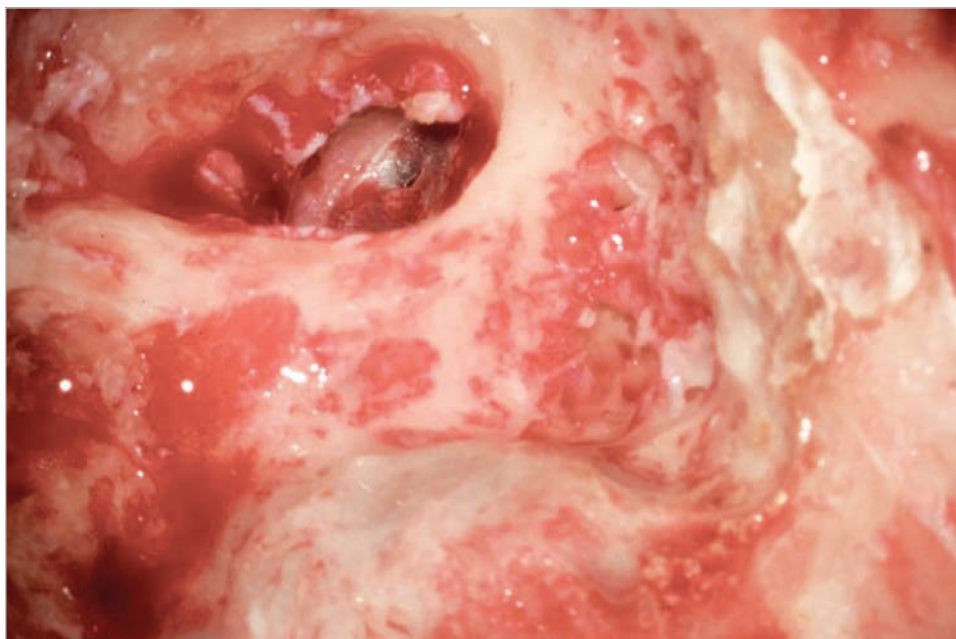


Fig. 14.586 At the beginning of mastoidectomy, the sigmoid sinus and the middle fossa dura are identified. No cholesteatoma is seen in the mastoid.

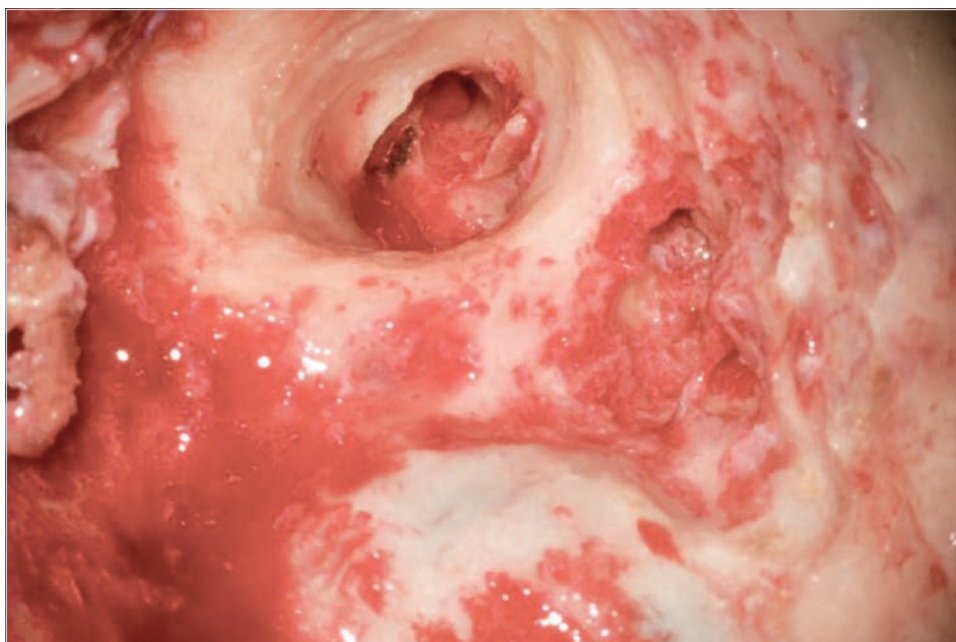


Fig. 14.587 The meatal skin and the tympanic membrane are removed. No cholesteatoma is seen in the mesotympanum.

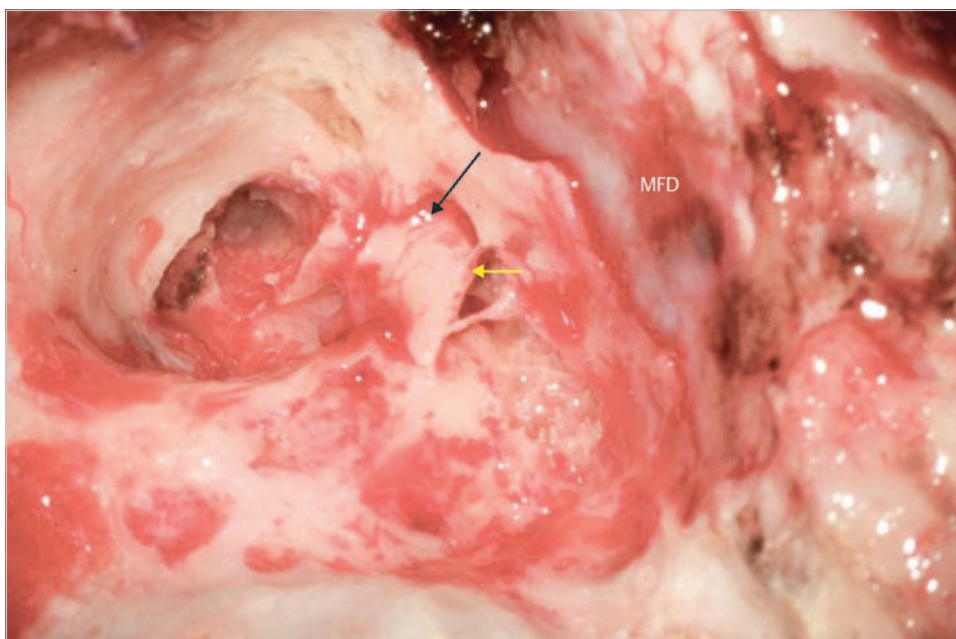


Fig. 14.588 The middle fossa dura is exposed, and the attic is partially opened. No cholesteatoma is seen around the ossicular chain. The incus (*yellow arrow*) and the head of the malleus (*black arrow*) are seen. MFD, middle fossa dura.

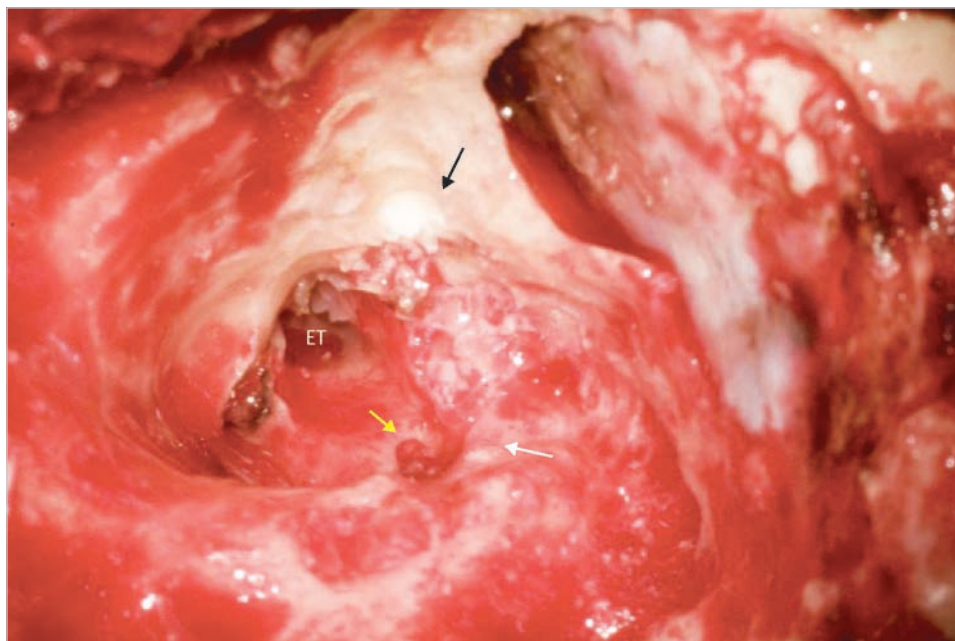


Fig. 14.589 The malleus and the incus are removed. The stapes (*yellow arrow*) is seen under the facial nerve (*white arrow*). Drilling of the anterosuperior wall of the external auditory canal exposed lateral part of cholesteatoma. ET, eustachian tube.

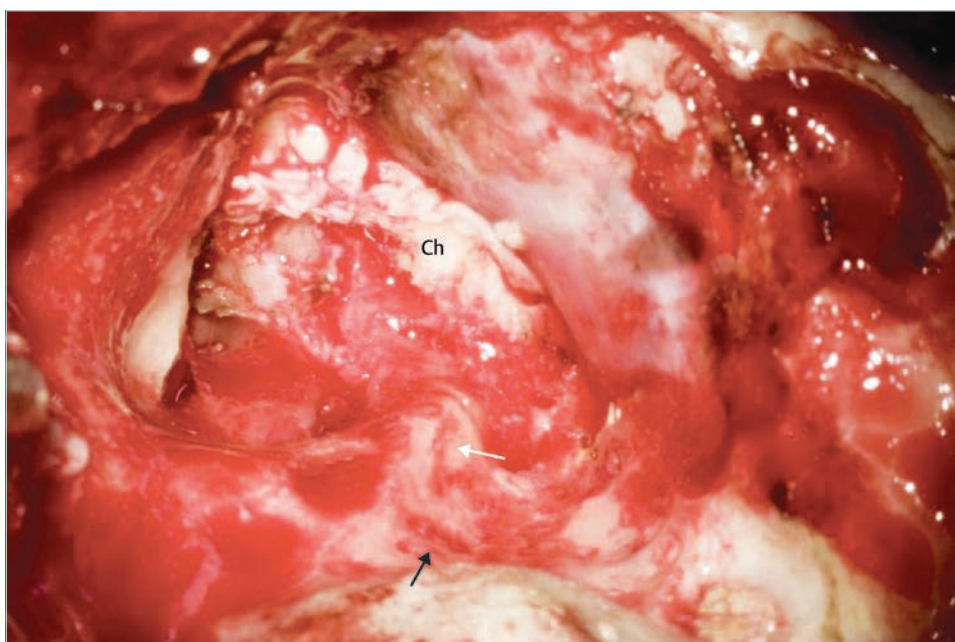


Fig. 14.590 Removal of the anterosuperior wall of the attic exposed cholesteatoma infiltrating between the petrous bone and the middle fossa dura. Labyrinthectomy is carried out to open the lateral (*white arrow*) and the posterior (*black arrow*) semicircular canals. Ch, cholesteatoma.

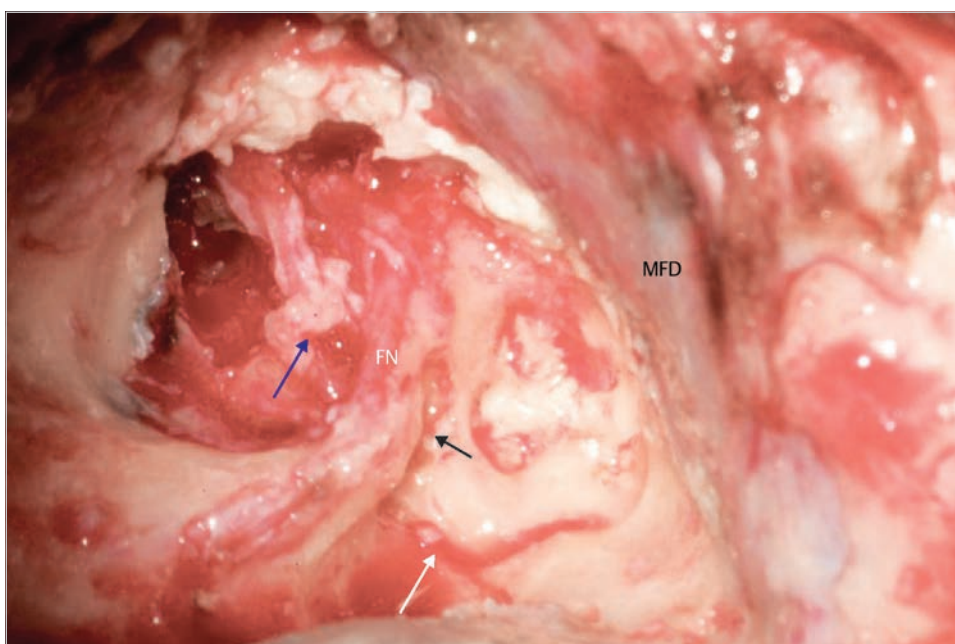


Fig. 14.591 The cholesteatoma passes under the facial nerve to erode the cochlea (*blue arrow*). Further drilling of semicircular canals exposed cholesteatoma located medially to the labyrinth. The vestibule (*black arrow*) and the common crus (*white arrow*) are seen. The facial nerve is exposed for reconstruction conducted later on. FN, facial nerve; MFD, middle fossa dura.

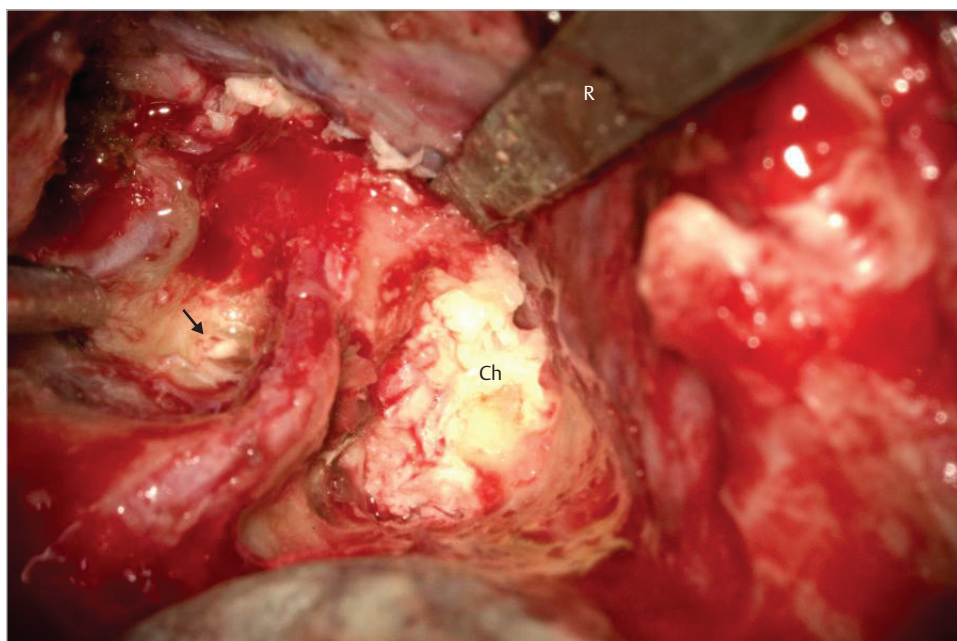


Fig. 14.592 Removal of the labyrinth revealed extensive cholesteatoma in the petrous apex. The medial wall of the tympanic cavity is started to be drilled. Partially opened cochlea is seen (*arrow*). Ch, cholesteatoma; R, retractor.

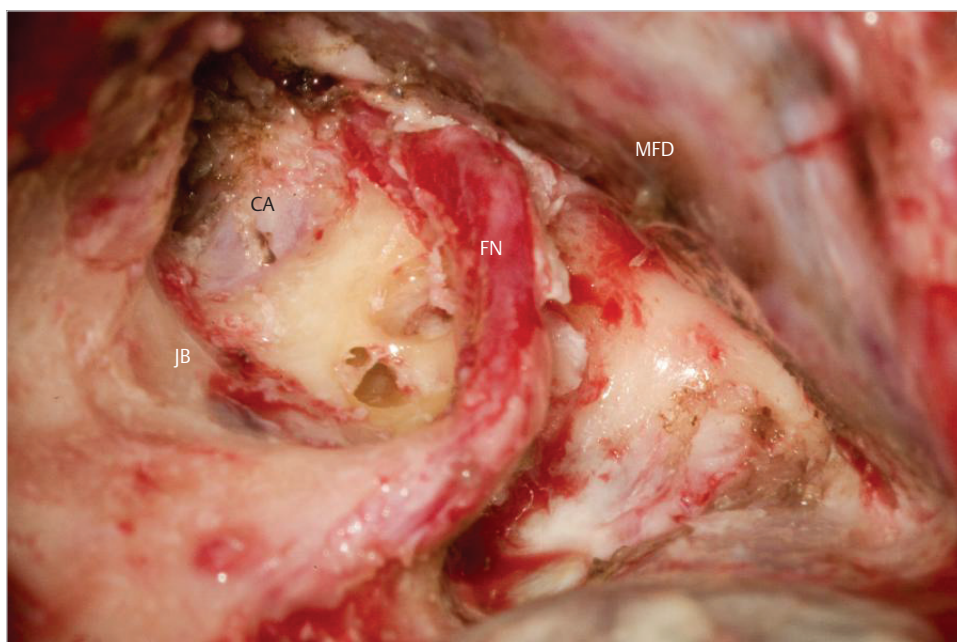


Fig. 14.593 The cholesteatoma is removed from the posterior fossa dura. Note that the medial face of the tympanic segment of the facial nerve is covered with the cholesteatoma. The carotid artery coursing near the cochlea is seen (*arrow*). CA, carotid artery; FN, facial nerve; JB, jugular bulb; MFD, middle fossa dura.



Fig. 14.594 Since the facial nerve is severely damaged, reconstruction of the nerve with cable grafting is indicated. To remove damaged portion and to eradicate cholesteatoma medially to the nerve, the great superficial petrosal nerve connecting the nerve to the middle fossa dura is coagulated (*arrow*). BT, basal turn of cochlea; CA, carotid artery; ET, eustachian tube; FN, facial nerve; 2T, second turn of cochlea.

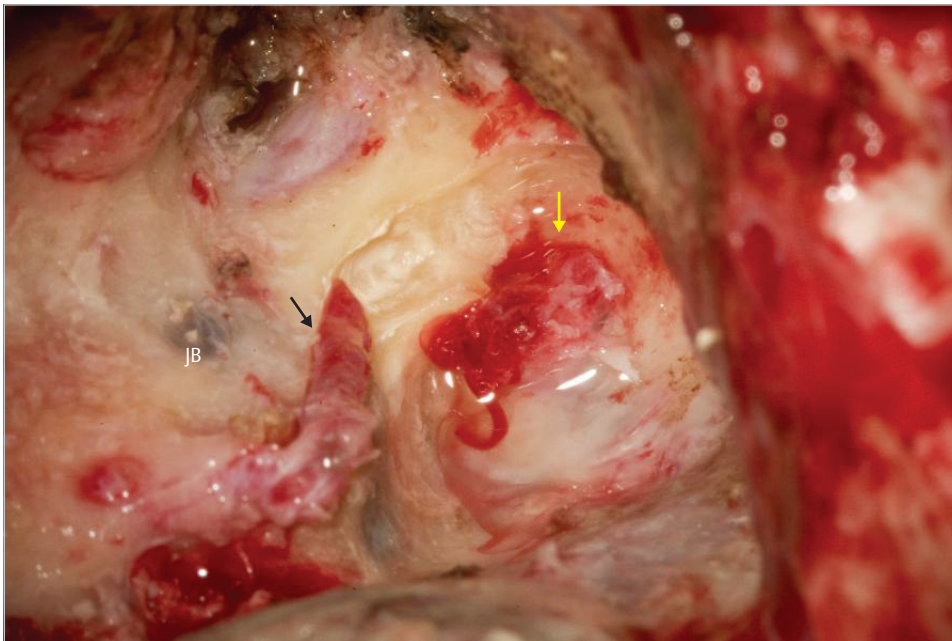


Fig. 14.595 The facial nerve is transected. This facilitates total removal of the cholesteatoma from the temporal bone. The healthy distal segment of the facial nerve (*black arrow*) and the porus of the internal auditory canal (*yellow arrow*) that include proximal of the facial nerve stump are seen. JB, jugular bulb.

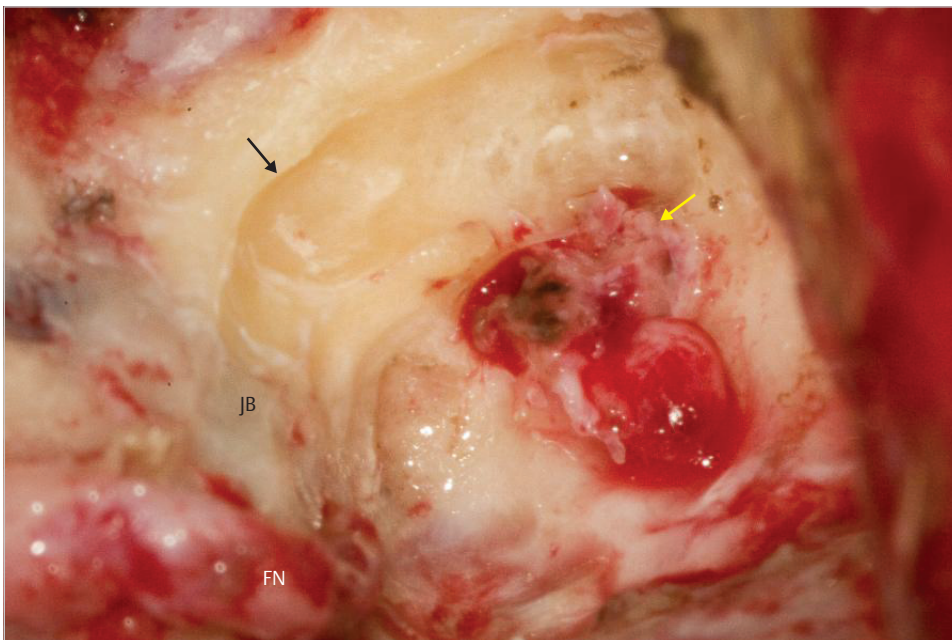


Fig. 14.596 The proximal stump of the facial nerve occupying anterosuperior part of the internal auditory canal is shown (*yellow arrow*). The nerve reflected posteriorly is the vestibular nerve. A groove to accommodate the reconstructed facial nerve (*black arrow*) is created using the basal turn of the cochlea. FN, facial nerve (distal stump); JB, jugular bulb.

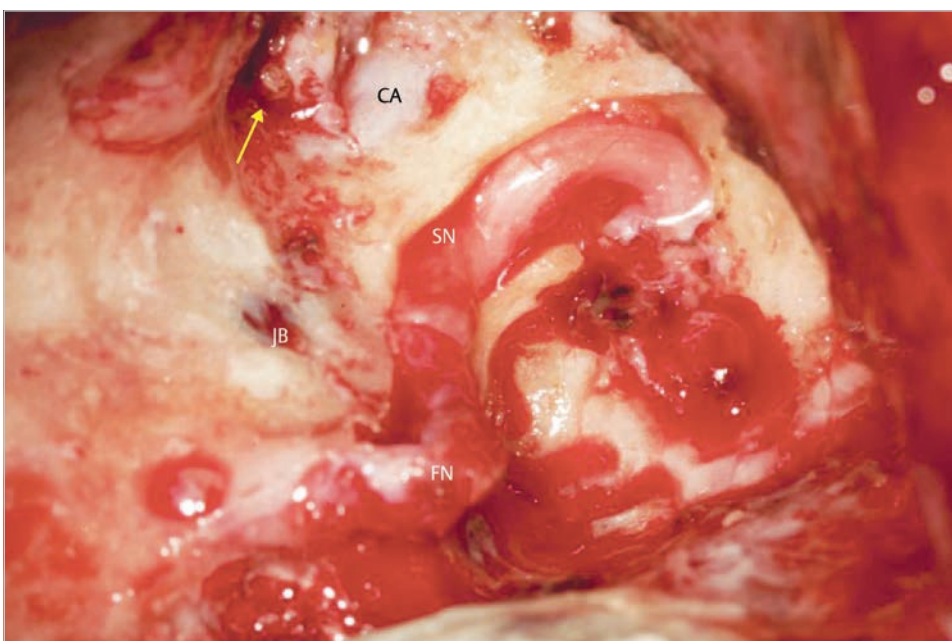


Fig. 14.597 The facial nerve is reconstructed using the sural nerve as a graft. The reconstructed nerve is placed in the groove created using the basal turn of the cochlea for stabilization. Both junctions are fixed with fibrin glue. The eustachian tube is obliterated with perichondrium (*arrow*). The cavity is obliterated with abdominal fat in following procedure. CA, carotid artery; FN, facial nerve; JB, jugular bulb; SN, sural nerve graft.

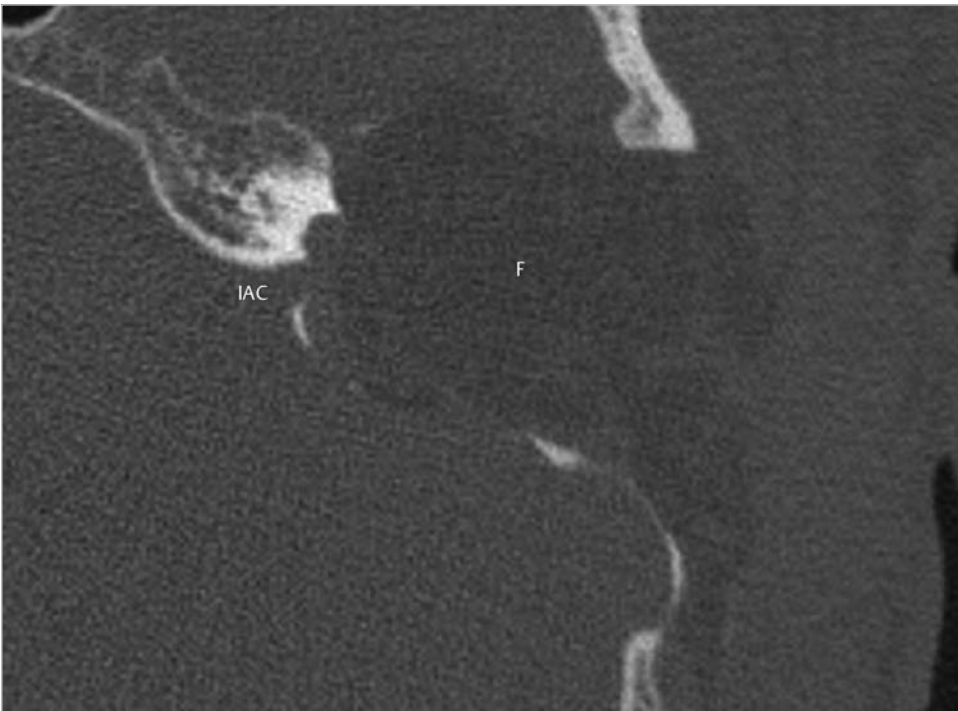


Fig. 14.598 The axial CT at the level of the internal auditory canal demonstrates extensive removal of bone from the petrous apex. F, abdominal fat; IAC, internal auditory canal.

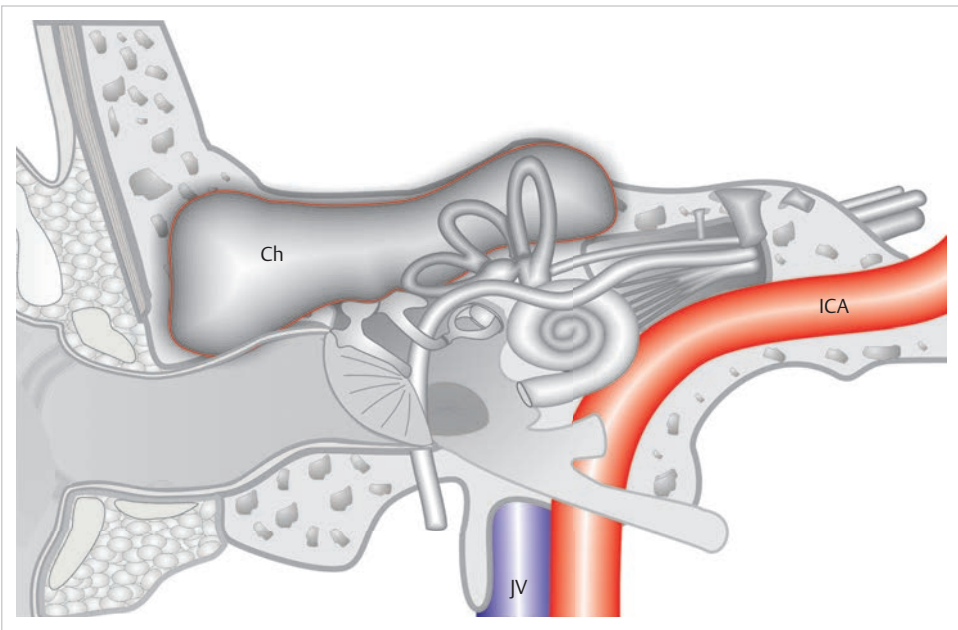


Fig. 14.599 An acquired supralabyrinthine petrous bone cholesteatoma partially eroding the superior and the lateral semicircular canals treated with middle fossa approach combined with transmastoid approach. To save hearing of this ear, the surgery to the right ear is planned immediately after recovery from the surgery on the left ear. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

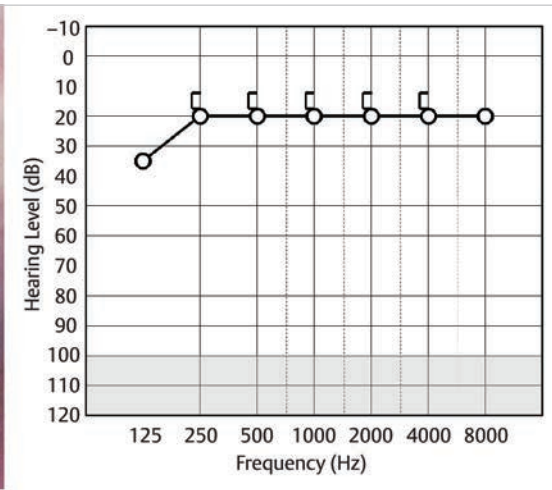


Fig. 14.600 The otoscopy of the right ear of the same patient. The posterior half of the tympanic membrane is scarred and touched to the promontory. The posterosuperior quadrant goes deep toward the attic, touching to the superstructure of the stapes (arrow). This spontaneous myringostapediopexy explains preoperative very good hearing.

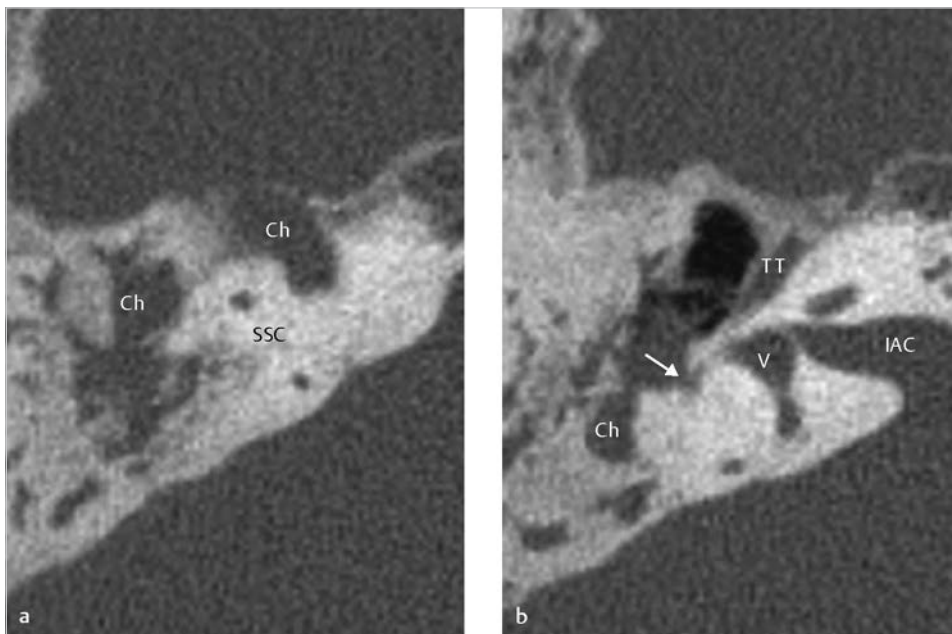


Fig. 14.601 The axial CT shows medial extension of cholesteatoma surpassing the superior semicircular canal. Even though the tympanic cavity is pneumatized to some extent, a small labyrinthine fistula is identified in the lateral semicircular canal (*arrow*). The head of the malleus and the whole incus are missing in the attic. Ch, cholesteatoma; IAC, internal auditory canal; SSC, superior semicircular canal; TT, tensor tympani; V, vestibule.

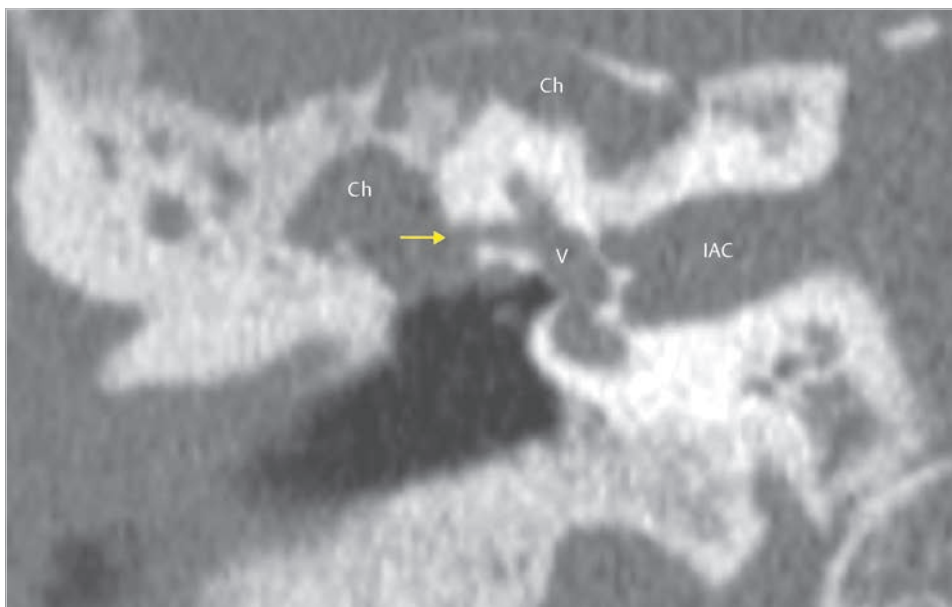


Fig. 14.602 In coronal view, a fistula in the lateral semicircular canal is clearly seen (*arrow*). The cholesteatoma infiltrates medially along the middle fossa plate to reach the petrous apex. Ch, cholesteatoma; IAC, internal auditory canal; V, vestibule.



Fig. 14.603 Since the patient already underwent left transotic approach with reconstruction of the facial nerve, preservation of hearing is of primary concern. Transmastoid approach combined with middle fossa approach is indicated for that sake. Bone work in the mastoid cavity is completed, and the cholesteatoma reaching the mastoid has been removed already at this moment.

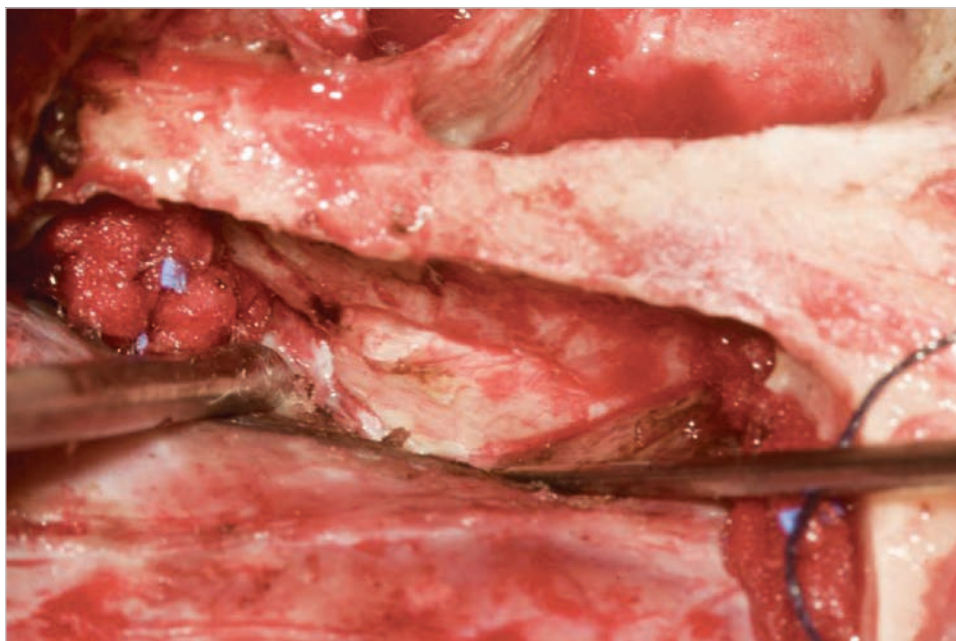


Fig. 14.604 Through middle fossa approach, the superior face of the petrous bone is exposed from superior. The cholesteatoma eroding the tegmen of the mastoid is seen. The left side of the picture corresponds to the anterior of the patient, the top corresponds to caudal, and the bottom cephalad.

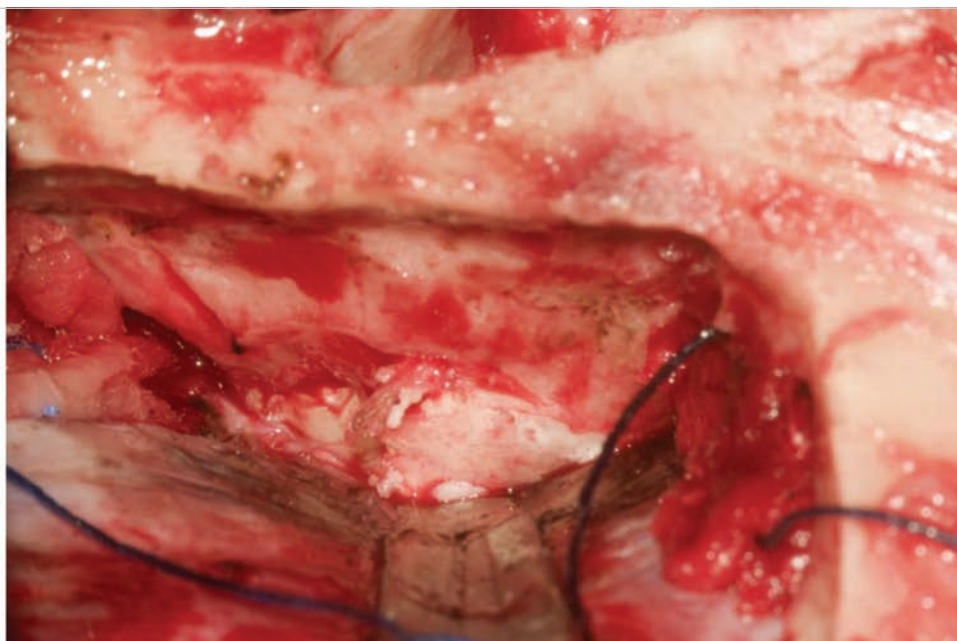
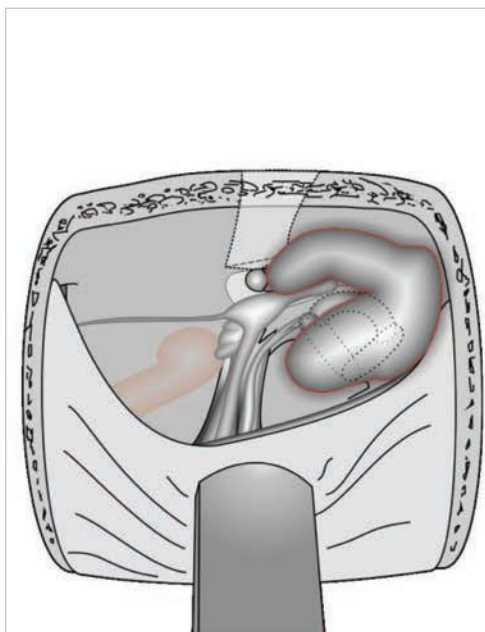


Fig. 14.605 A retractor is used to hold the middle fossa dura superiorly.

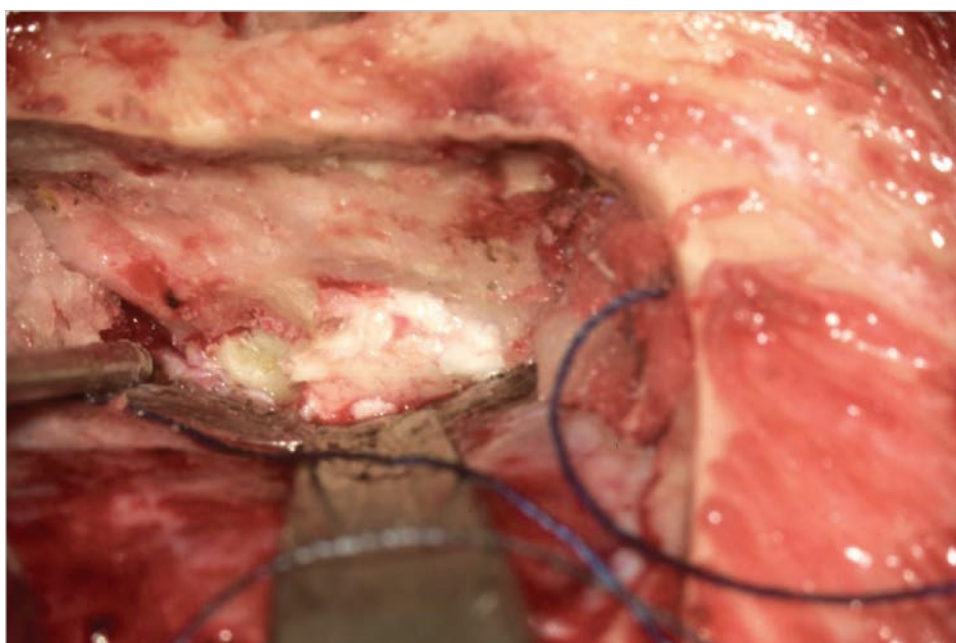


Fig. 14.606 The cholesteatoma is started to be dissected.

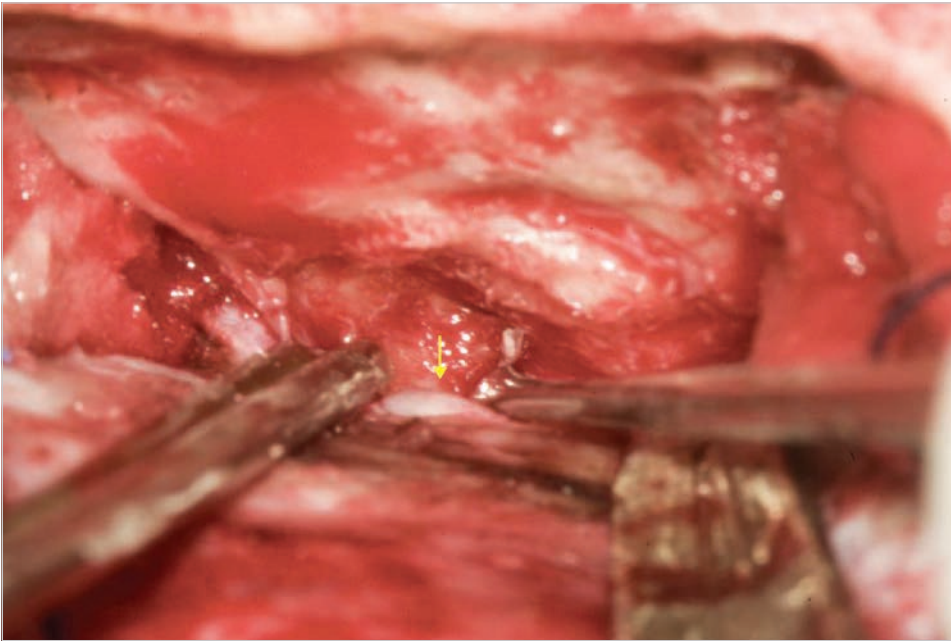


Fig. 14.607 There is still cholesteatoma present (arrow) covering the dura.

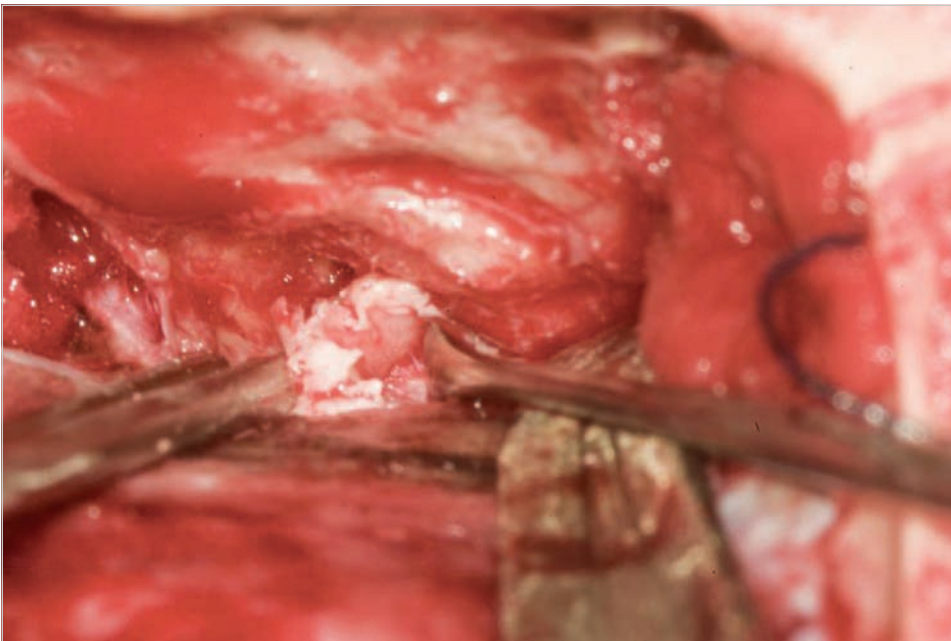


Fig. 14.608 The cholesteatoma is detached from the dura.

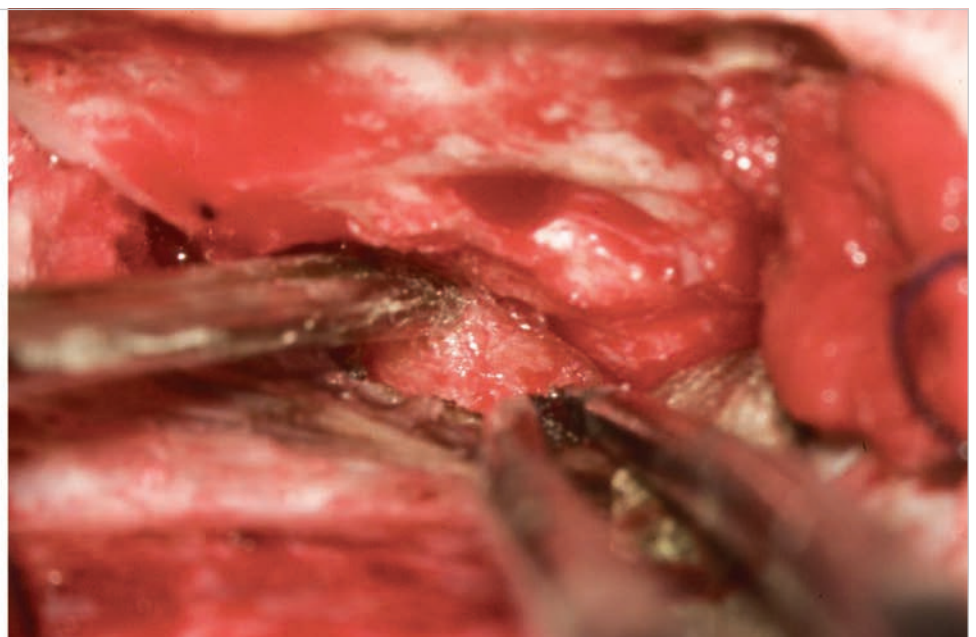
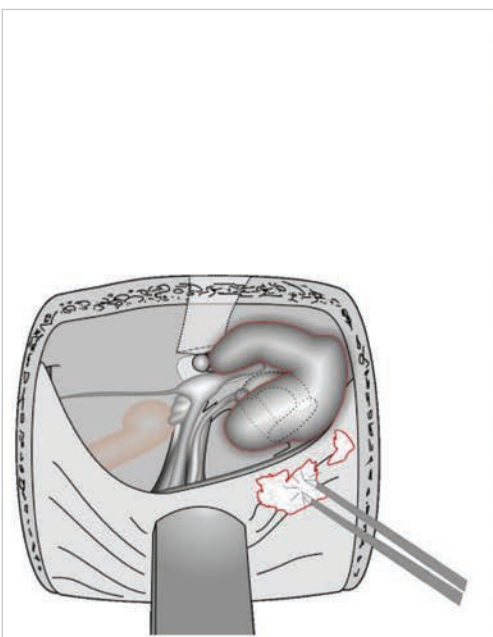


Fig. 14.609 The area of the dura suspicious of residual matrix should be coagulated with bipolar.

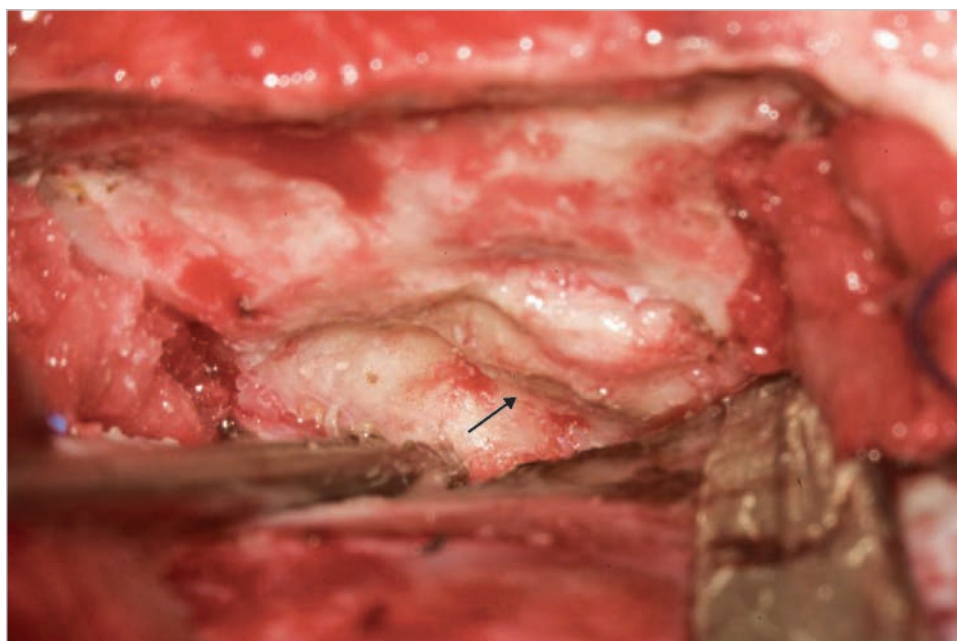


Fig. 14.610 Cholesteatoma infiltrating medially to the superior semicircular canal (*arrow*) is eradicated.

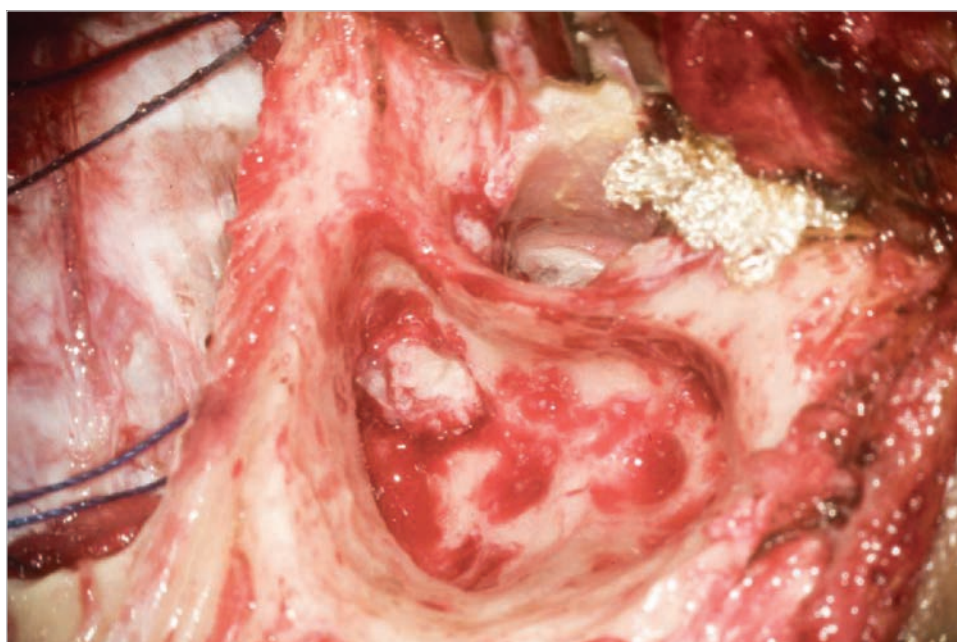


Fig. 14.611 The retractor is removed, and the surgery is conducted from the mastoid again. Cholesteatoma in the attic is shown.



Fig. 14.612 Some debris has been evacuated from the mastoid. The cholesteatoma fills the entire attic.

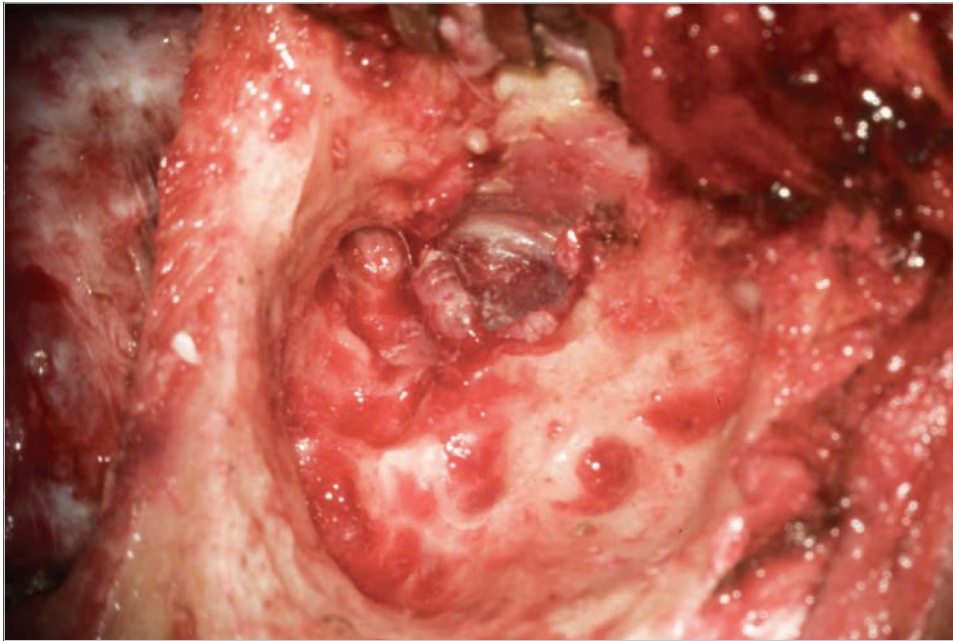


Fig. 14.613 The cholesteatoma is eradicated from the middle ear. Since this is the cholesteatoma surgery in only hearing ear, removal of posterior wall to reduce possibility of both recurrent and residual cholesteatoma is indicated. Since preoperative hearing is good, the tympanic membrane is left untouched.

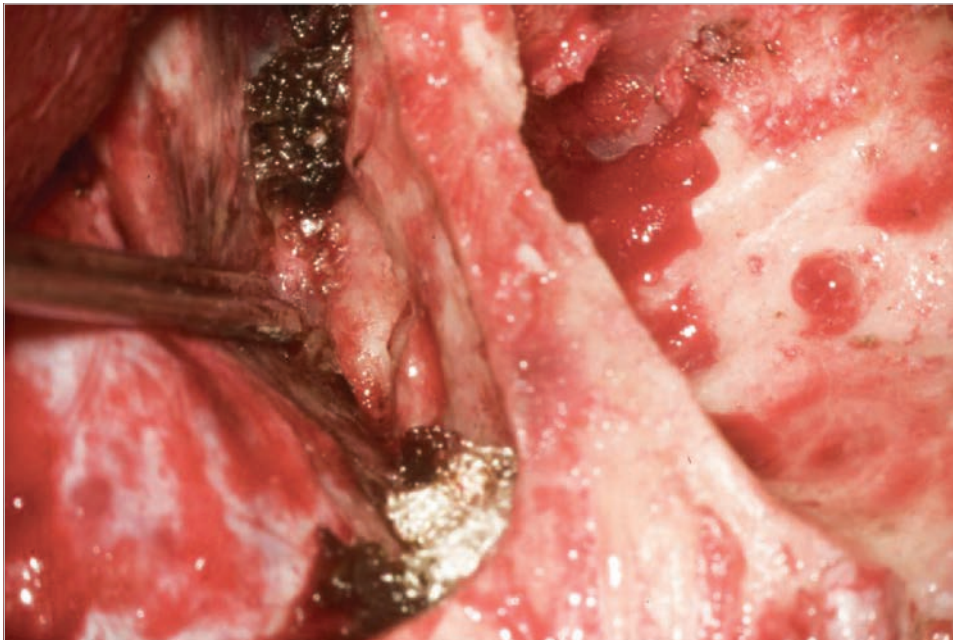


Fig. 14.614 View from the middle fossa. Absence of residual skin is verified.



Fig. 14.615 From the middle fossa, the tegmen is reconstructed with a large piece of fascia and cartilage. The cartilage is held in place with Gelfoam. The bone flap is replaced to cover the lateral face of the middle cranial fossa. The mastoid cavity is covered with fascia and the cavity is reconstructed in the same manner as a canal wall down tympanoplasty.

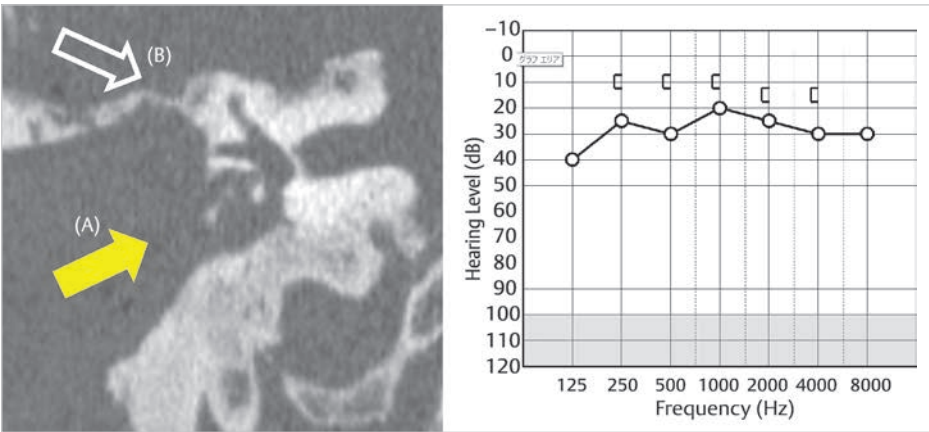


Fig. 14.616 The CT conducted immediately postoperatively clearly demonstrates two approaches, transmastoid (a) and middle fossa (b). The hearing stays near-normal postoperatively due to preserved configuration of the tympanic cavity.

Case 14.26 (Left Ear)

See ▶ Fig. 14.617, ▶ Fig. 14.618, ▶ Fig. 14.619, ▶ Fig. 14.620, ,
▶ Fig. 14.623, ▶ Fig. 14.624, ▶ Fig. 14.625, ▶ Fig. 14.626, ▶ Fig. 14.627,
▶ Fig. 14.628, ▶ Fig. 14.629, ▶ Fig. 14.630, ▶ Fig. 14.631.

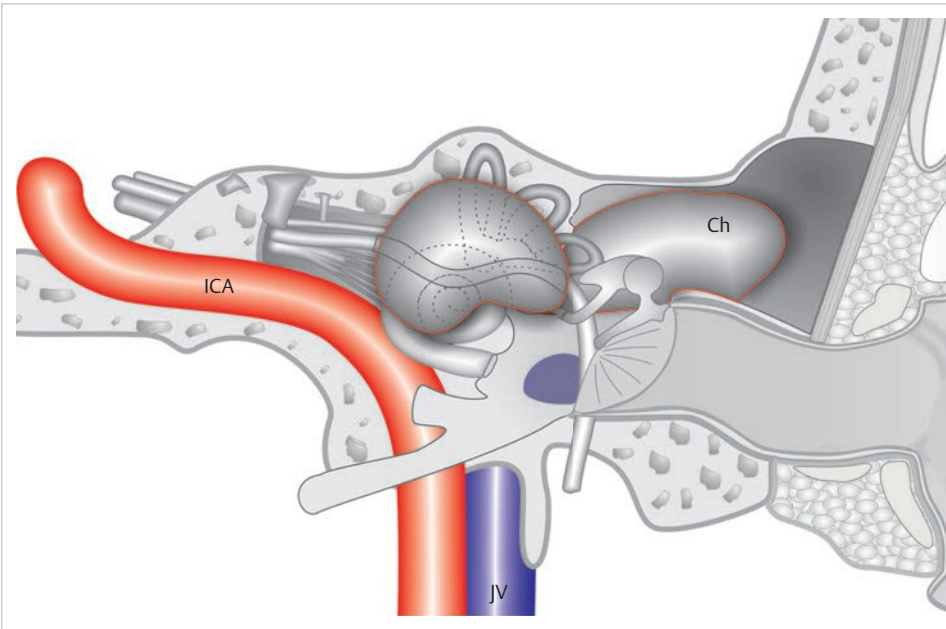


Fig. 14.617 A case of massive petrous bone cholesteatoma treated with modified transcochlear approach combined with infratemporal fossa approach type B with facial nerve reconstruction. Preoperative facial nerve function was H-B grade VI. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.

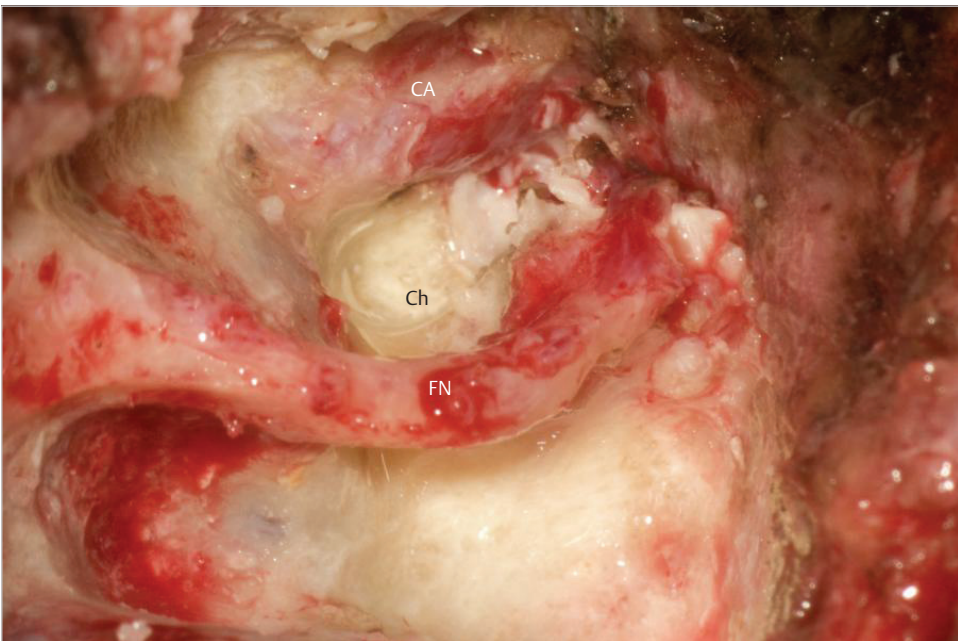


Fig. 14.618 The otic capsule is already removed including the cochlea. The entire course of the facial nerve in the fallopian canal and the vertical segment of the carotid artery are skeletonized. Note the huge cholesteatoma occupying the medial part of the temporal bone. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve.

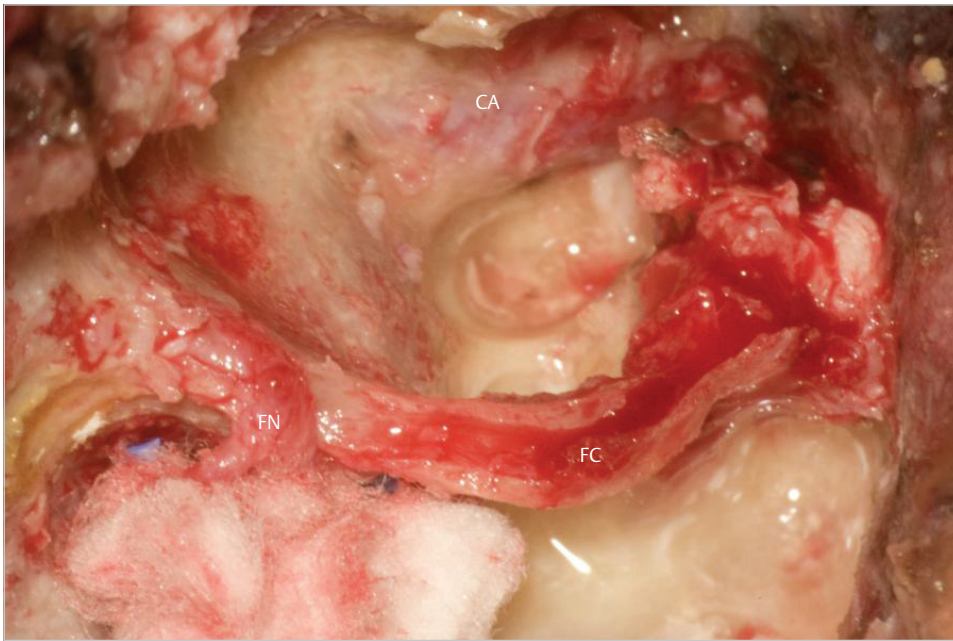


Fig. 14.619 Since the facial nerve is severely damaged at the level of the geniculate ganglion and the labyrinthine segment, the nerve is transected in the tympanic segment. The distal end of the nerve is detached from the fallopian canal and secured with the cottonoid. CA, carotid artery; FC, fallopian canal; FN, facial nerve.

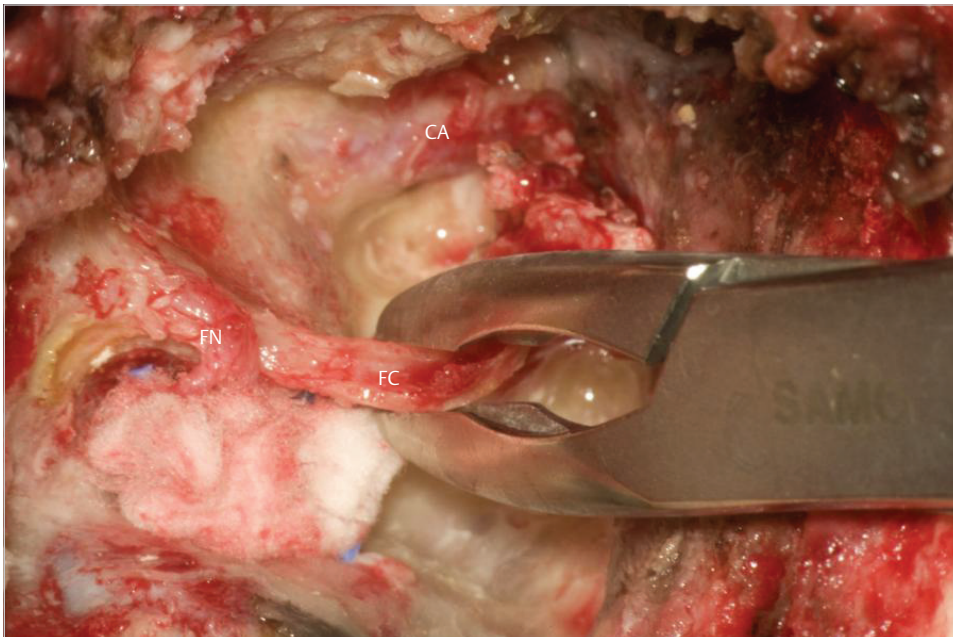


Fig. 14.620 The fallopian canal is removed with a rongeur. CA, carotid artery; FC, fallopian canal; FN, facial nerve.



Fig. 14.621 The proximal end of the nerve inflamed and severely damaged by the cholesteatoma is shown. CA, carotid artery; FC, fallopian canal; FN, facial nerve.



Fig. 14.622 The cholesteatoma encompasses the geniculate ganglion, and infiltrates medially to it. CA, carotid artery.



Fig. 14.623 The cholesteatoma around the geniculate ganglion is started to be dissected. CA, carotid artery; Ch, cholesteatoma; FN, facial nerve (proximal end); MFD, middle fossa dura.

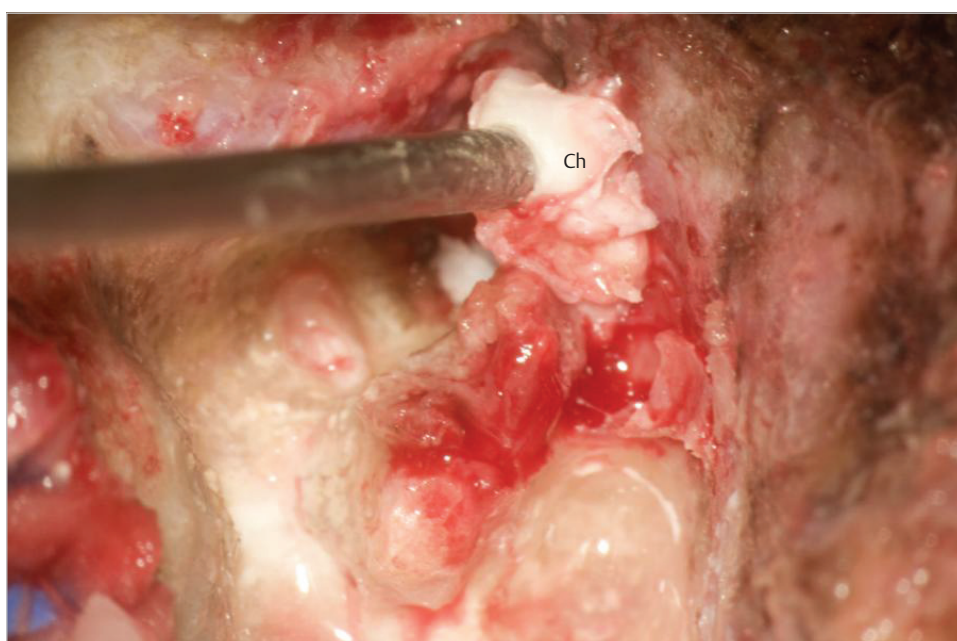


Fig. 14.624 The debris between the dura and the facial nerve is evacuated, and the matrix is detached from the dura with meticulous care. Ch, cholesteatoma.



Fig. 14.625 The matrix anteromedially to the geniculate ganglion is shown.



Fig. 14.626 The bone anteriorly to the internal auditory canal is removed to eradicate cholesteatoma. The distal half of the internal auditory canal with contents is seen.

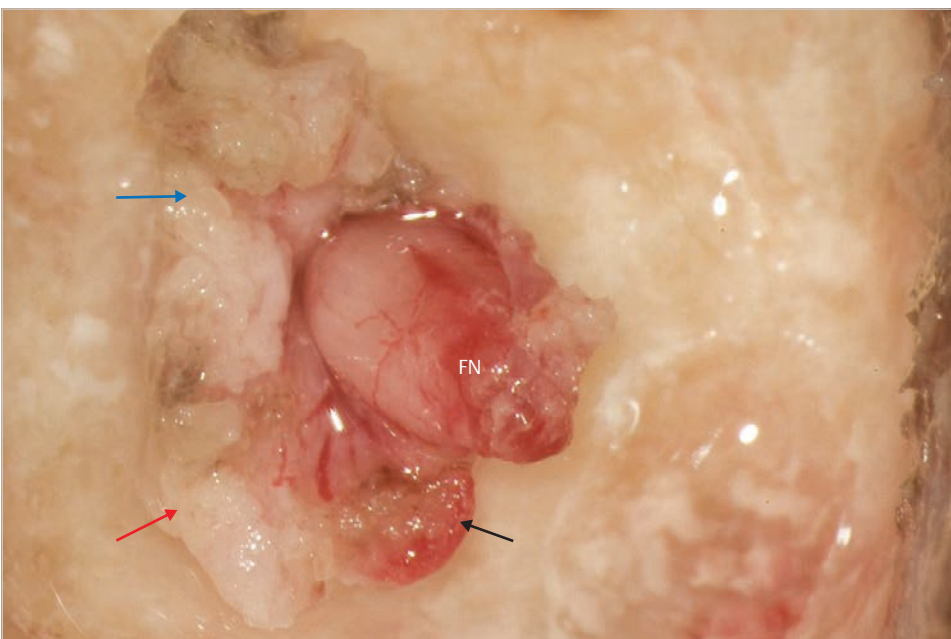


Fig. 14.627 Contents of the lateral part of the internal auditory canal is dissected. The proximal end of the facial nerve (FN) is further exposed and refreshed with sharp malleable scissors. The black arrow indicates the superior vestibular nerve located behind the facial nerve. The soft tissue inferiorly to the facial nerve corresponds to the distal end of the cochlear nerve (*blue arrow*). The inferior vestibular nerve (*red arrow*) is seen posterior to it.



Fig. 14.628 The distal end of the facial nerve corresponding to the mastoid segment is seen. FN, facial nerve.

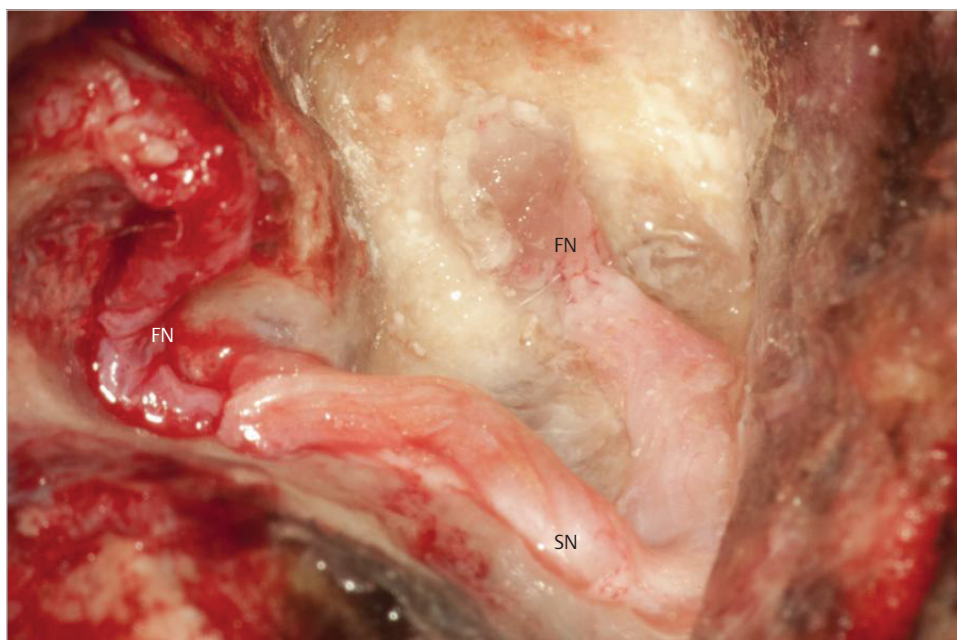


Fig. 14.629 The sural nerve is in position. FN, facial nerve; SN, sural nerve.



Fig. 14.630 The proximal end of the anastomosis is fixed with fibrin glue.



Fig. 14.631 Two anastomoses are secured with pieces of periosteum, and fibrin glue is applied over it. PO, periosteum.

Case 14.27 (Left Ear)

See ▶Fig. 14.632, ▶Fig. 14.633, ▶Fig. 14.634, ▶Fig. 14.635, ▶Fig. 14.636, ▶Fig. 14.637, ▶Fig. 14.638, ▶Fig. 14.639, ▶Fig. 14.640, ▶Fig. 14.641, ▶Fig. 14.642, ▶Fig. 14.643, ▶Fig. 14.644, ▶Fig. 14.645, ▶Fig. 14.646, ▶Fig. 14.647, ▶Fig. 14.648, ▶Fig. 14.649.

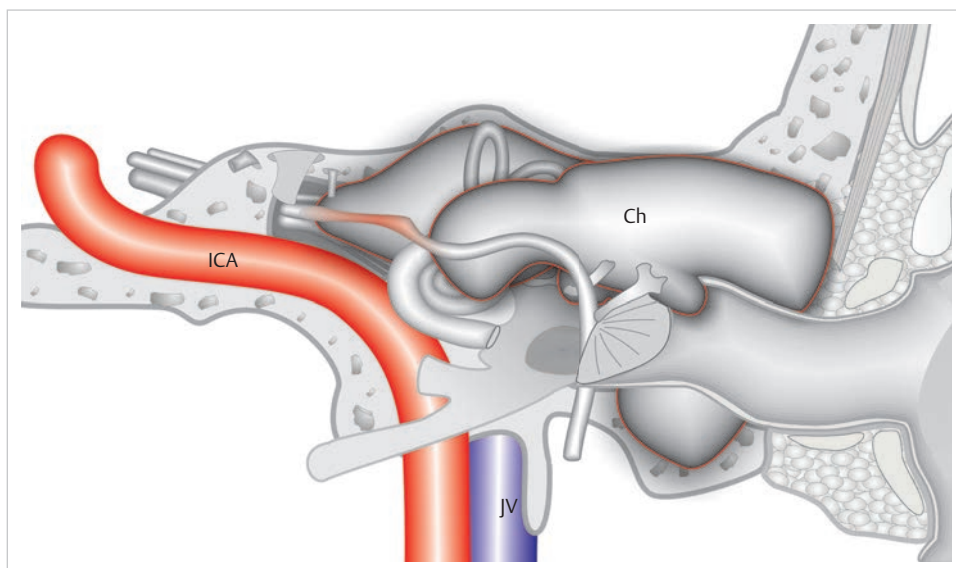


Fig. 14.632 A case of acquired massive petrous bone cholesteatoma arose from the pars flaccida of tympanic membrane treated with transotic approach combined with infratemporal fossa approach type B with facial nerve reconstruction. The preoperative facial nerve function was H-B grade VI. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular vein.



Fig. 14.633 The posterior canal wall is partially removed, and the anterior wall is calibrated. A small erosion is seen in pars flaccida. The cholesteatoma filling the entire mastoid has been removed. The pars tensa of the tympanic membrane stays in good shape. The middle fossa dura and the sigmoid sinus are skeletonized, but not exposed at this moment. MF, middle fossa.



Fig. 14.634 Approach to the middle ear is shown. Note wide exposure of the lateral face of the middle fossa and the posterior fossa dura posteriorly to the sigmoid sinus. MF, middle fossa; SS, sigmoid sinus.



Fig. 14.635 The middle fossa dura is exposed and coagulated with bipolar to get shrunk to make some room. Note that the cholesteatoma extensively infiltrates the air cell tract medially to the semicircular canals and the facial nerve.



Fig. 14.636 Enlarged view. Note little extension of cholesteatoma in the mesotympanum. No opening for the semicircular canals is seen, because they are ossified completely. In some case of petrous bone cholesteatoma, extension of matrix does not correlate severity of otoscopic finding, making preoperative diagnosis of extension not possible.



Fig. 14.637 The labyrinthectomy is completed, and the facial nerve is exposed to prepare for posterior rerouting. FN, facial nerve.



Fig. 14.638 Cholesteatoma is present medially to the facial nerve. Drilling of the medial wall of the mesotympanum is started. FN, facial nerve.

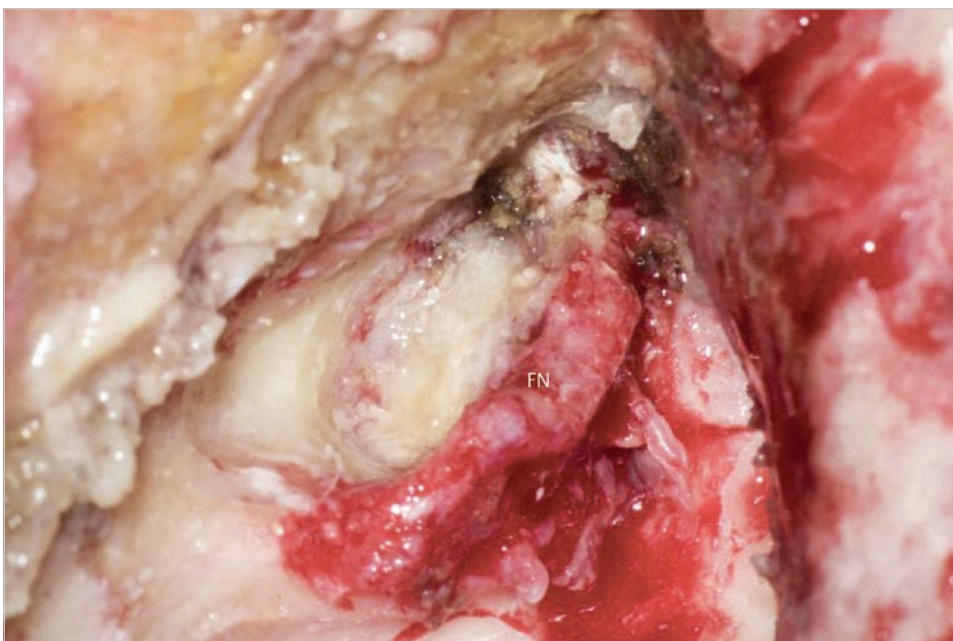


Fig. 14.639 Drilling is advanced medially, but no space is seen in the cochlea due to ossification. FN, facial nerve.



Fig. 14.640 The bone covering the geniculate ganglion is drilled.



Fig. 14.641 The internal auditory canal is opened posteriorly. Granulation tissue mingling with cholesteatoma matrix occupying the internal auditory canal is shown. FN, facial nerve; G, granulation tissue.

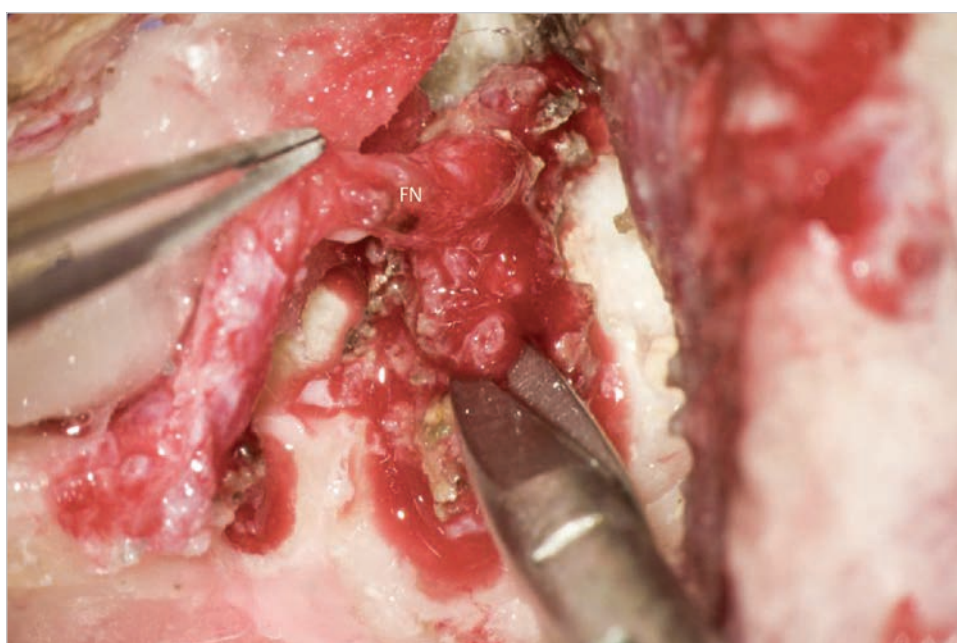


Fig. 14.642 The granulation tissue is reduced with scissors. FN, facial nerve.



Fig. 14.643 The dissection is in progress. Ch, cholesteatoma; ET, eustachian tube; FN, facial nerve.

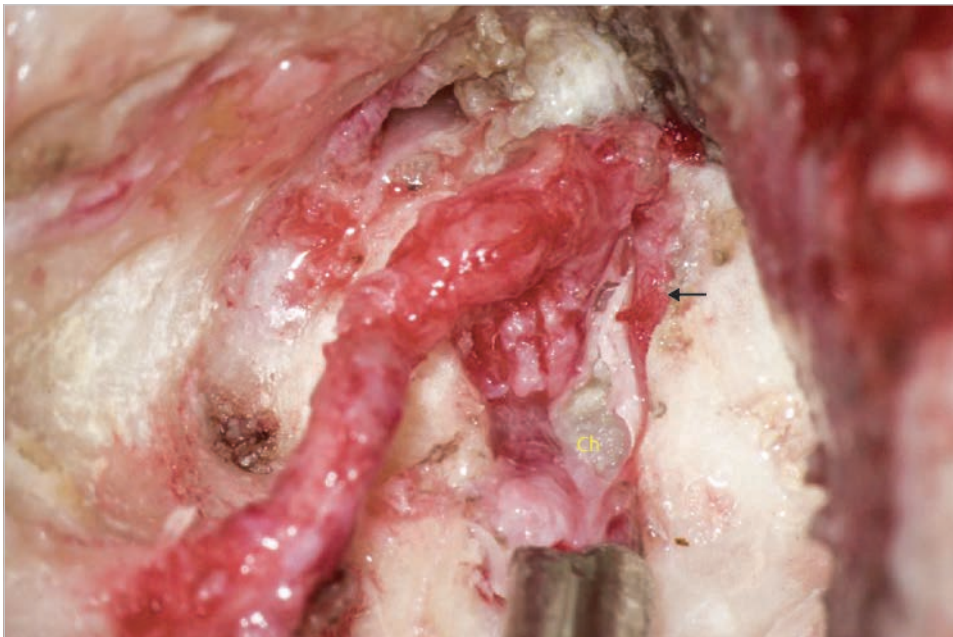


Fig. 14.644 Cholesteatoma infiltrating the internal auditory canal, covering the facial nerve (arrow) is shown. Ch, cholesteatoma.

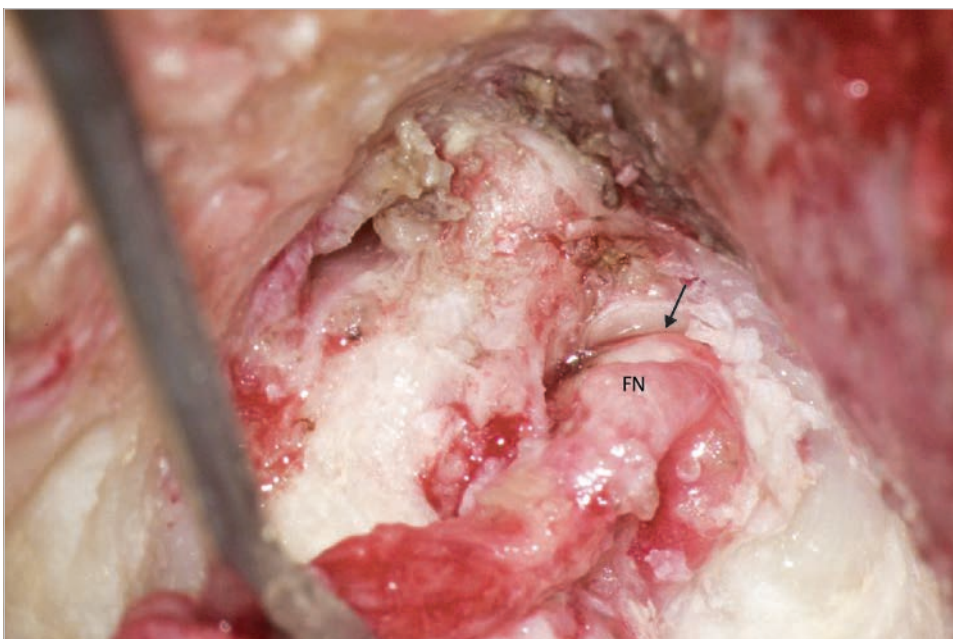


Fig. 14.645 After transecting the great superficial petrosal nerve, the facial nerve is moved posteriorly. The procedure exposed cholesteatoma located anteriorly to the internal auditory canal (arrow). FN, facial nerve.



Fig. 14.646 The cholesteatoma formed a large mass anteriorly to the internal auditory canal. The facial nerve is displaced posteriorly at this moment. Ch, cholesteatoma; ET, eustachian tube.



Fig. 14.647 The bone that was under the geniculate ganglion is drilled to enlarge access to the cholesteatoma located anteriorly to the internal auditory canal. FN, facial nerve.

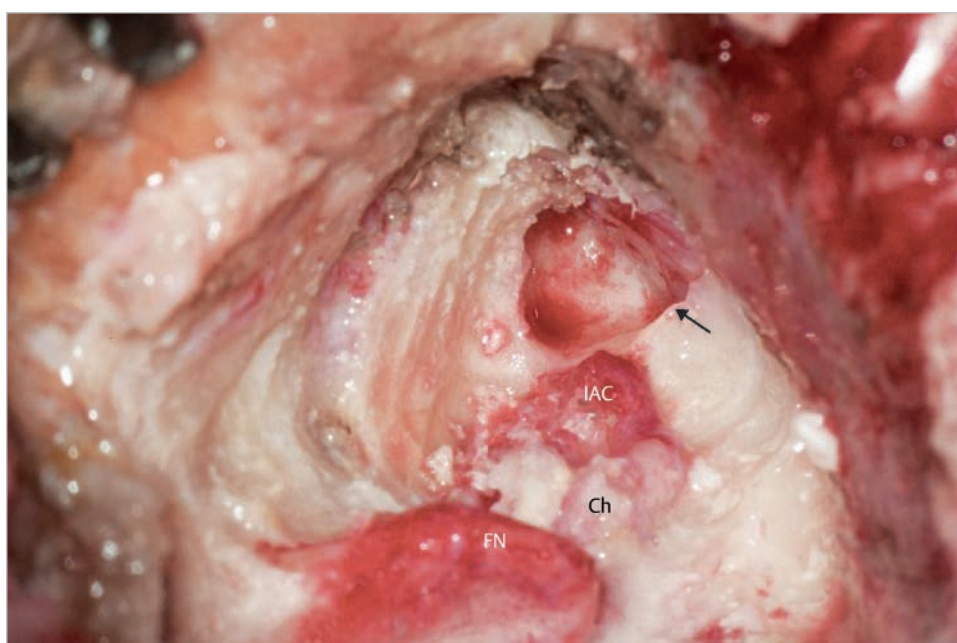


Fig. 14.648 The facial nerve is severed, and the cholesteatoma is removed from the large bony erosion anterior to the internal auditory canal (arrow). The cholesteatoma remains posteroinferiorly to the internal auditory canal. Ch, cholesteatoma; FN, facial nerve; IAC, internal auditory canal.

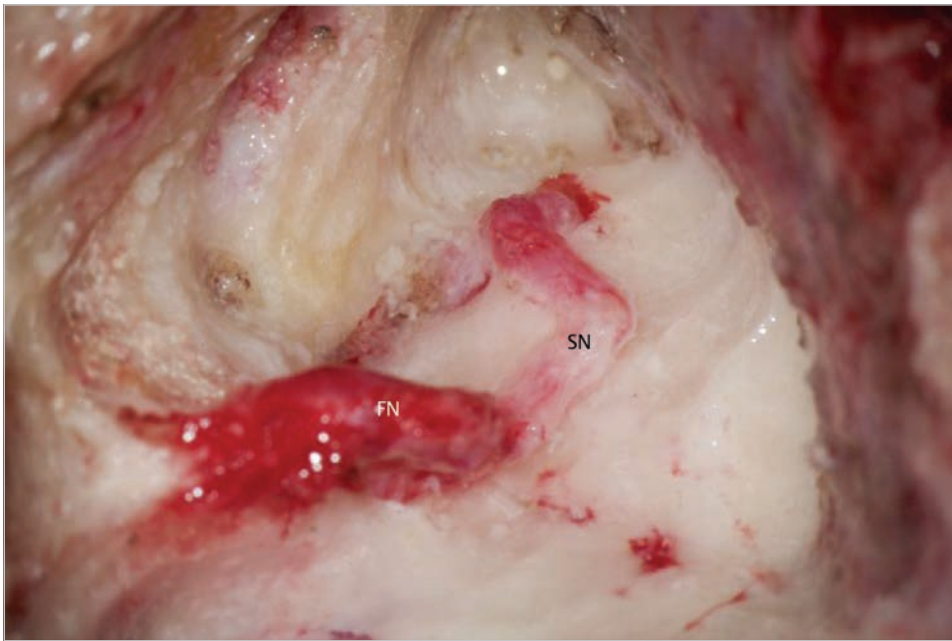


Fig. 14.649 After complete removal of the cholesteatoma, the facial nerve is reconstructed with cable nerve grafting using a sural nerve graft. The postoperative facial nerve function on the left face returned to H-B grade III. FN, facial nerve; SN, sural nerve graft.

Case 14.28 (Left Ear)

See ► Fig. 14.650, ► Fig. 14.651, ► Fig. 14.652, ► Fig. 14.653, ► Fig. 14.654, ► Fig. 14.655, ► Fig. 14.656, ► Fig. 14.657, ► Fig. 14.658, ► Fig. 14.659, ► Fig. 14.660, ► Fig. 14.661, ► Fig. 14.662, ► Fig. 14.663, ► Fig. 14.664, ► Fig. 14.665, ► Fig. 14.666, ► Fig. 14.667, ► Fig. 14.668, ► Fig. 14.669, ► Fig. 14.670, ► Fig. 14.671.

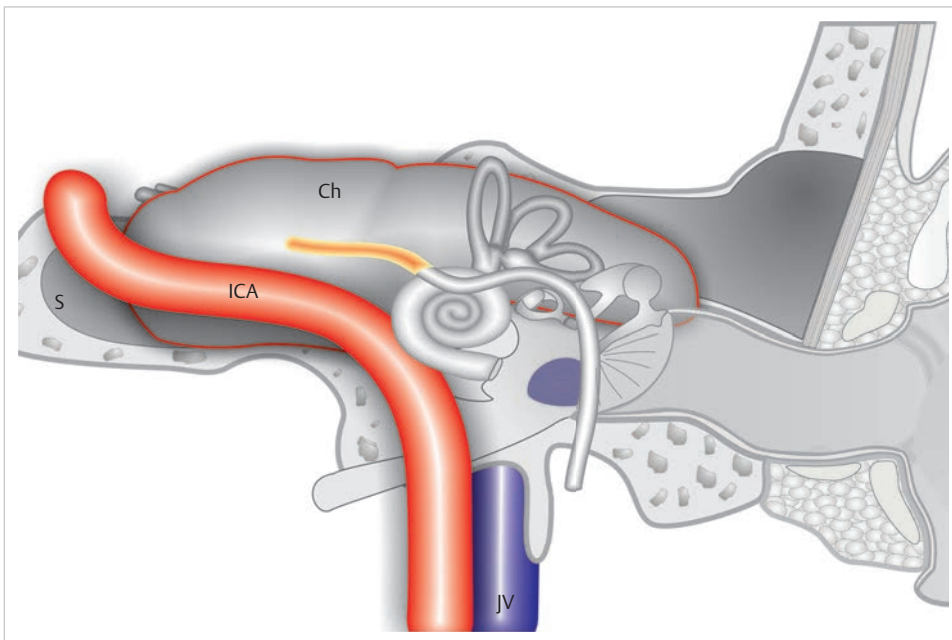


Fig. 14.650 A case of massive petrous bone cholesteatoma with intracranial and sphenoid extension. This 60-year-old patient underwent tympanoplasty elsewhere 10 years before. Even though no otorrhea was experienced, facial nerve palsy and hearing disturbance developed 5 years after the surgery. Physiologic examination revealed left anacusis together with complete left facial nerve palsy and well-compensated left vocal cord paralysis. Otoscopic examination revealed recurrence of cholesteatoma in the pars flaccida. Ch, cholesteatoma; ICA, internal carotid artery; JV, jugular bulb; S, sphenoid sinus.

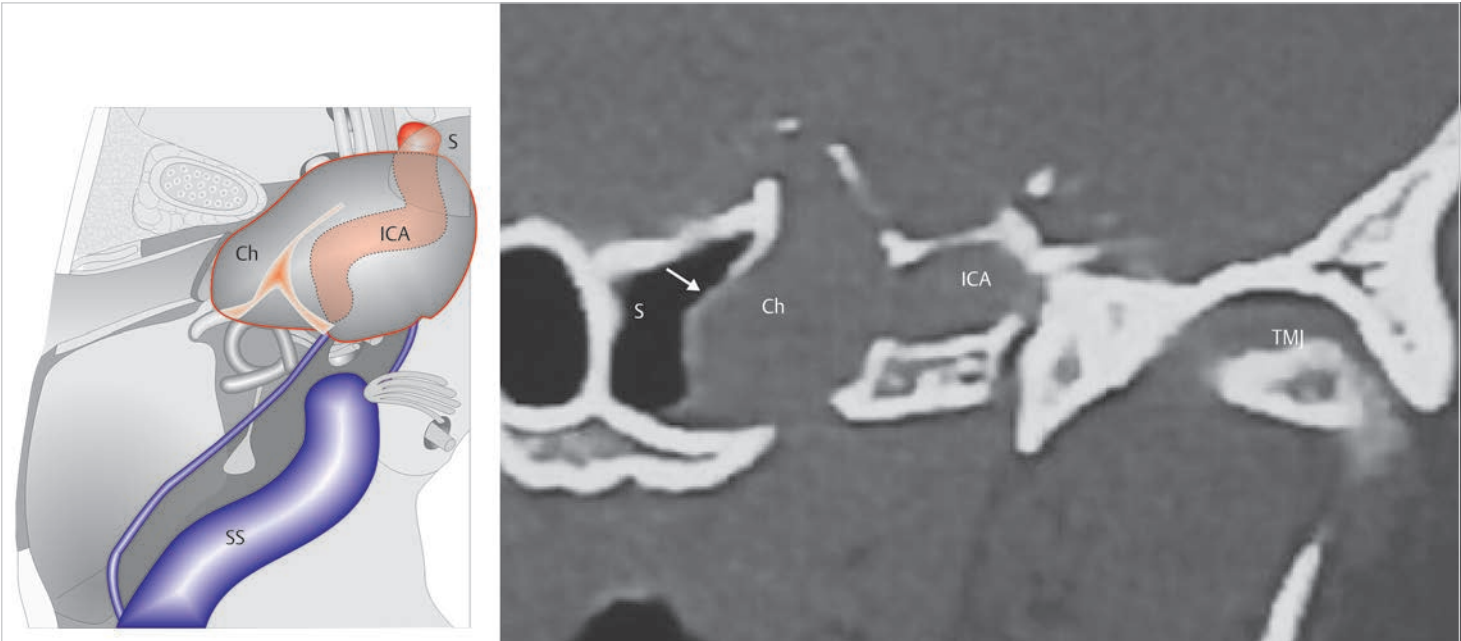


Fig. 14.651 The coronal CT shows extension of cholesteatoma medially to the horizontal segment of the carotid artery reaching the left sphenoid sinus (*arrow*). ICA, internal carotid artery; Ch, cholesteatoma; S, sphenoid sinus; SS, sigmoid sinus; TMJ, temporomandibular joint.

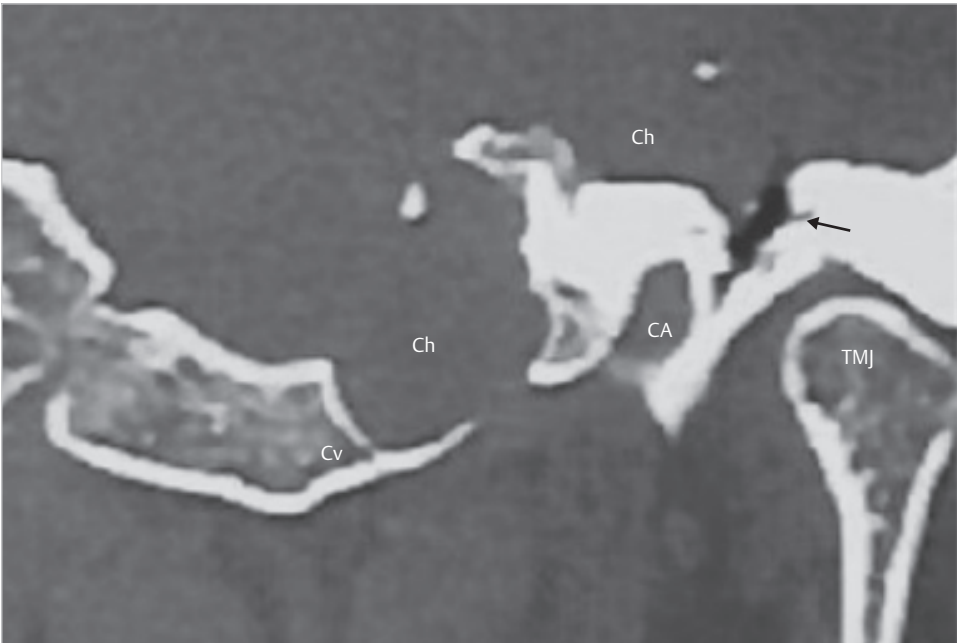


Fig. 14.652 More posterior section at the level of the vertical segment of the carotid artery demonstrates presence of cholesteatoma laterally to the protympanum (*red arrow*), and far inferomedial extension eroding the clivus. CA, carotid artery; Ch, cholesteatoma; Cv, clivus; TMJ, temporomandibular joint.

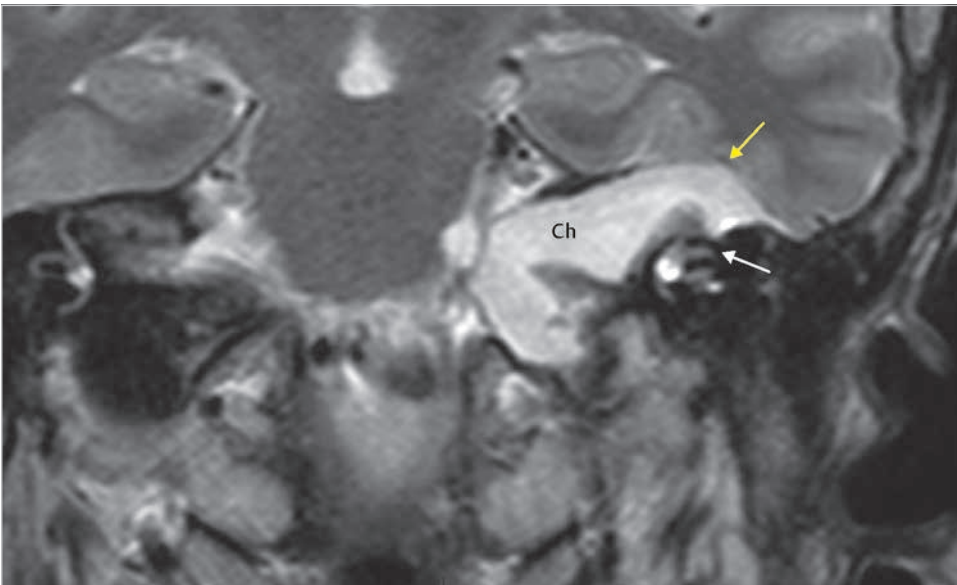


Fig. 14.653 MRI (coronal cut) shows the petrous bone cholesteatoma that from the supralabyrinthine compartment (*white arrow*) extends superiorly towards the temporal lobe (*yellow arrow*). Ch, cholesteatoma.

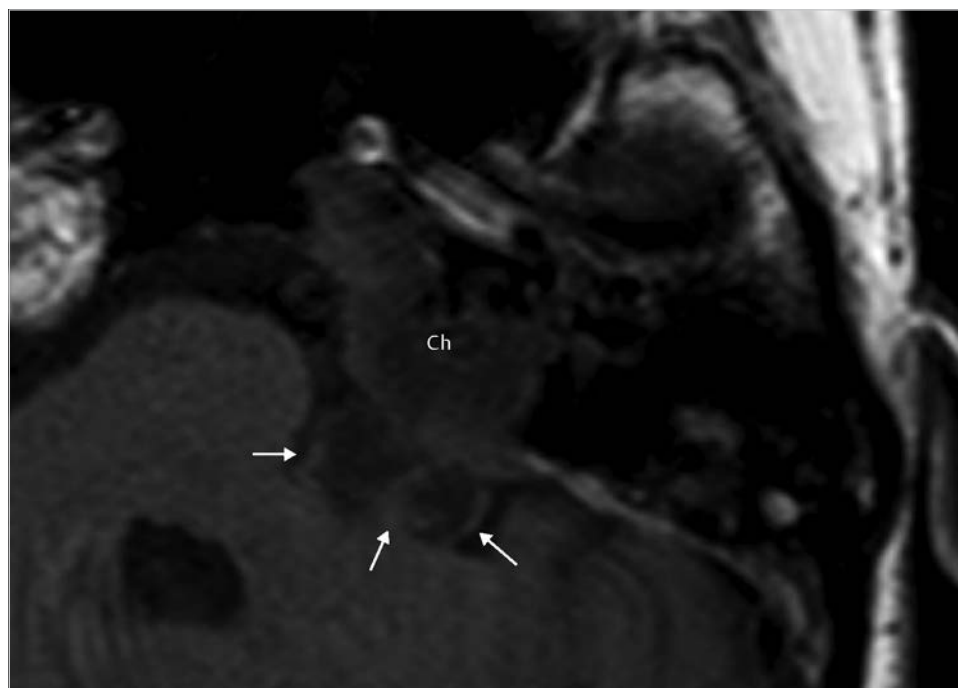


Fig. 14.654 The MRI shows compression of the brain stem by cholesteatoma protruding from the petrous apex (*arrows*). Ch, cholesteatoma.

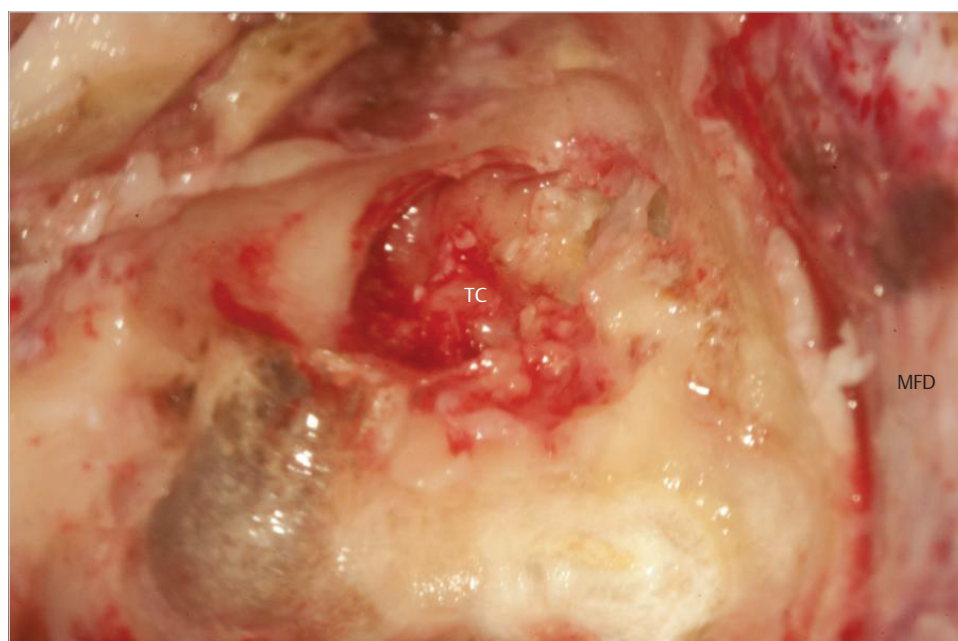


Fig. 14.655 The patient has very long history of left deafness and facial nerve palsy. The radiologic examinations show extensive cholesteatoma involving whole temporal bones with extension of cerebellopontine angle. Therefore, drilling of inner ear and severing of the facial nerve without reconstruction are indicated in this particular case. Canal wall down mastoidectomy with exposure of the middle fossa dura is conducted. MFD, middle fossa dura; TC, tympanic cavity.

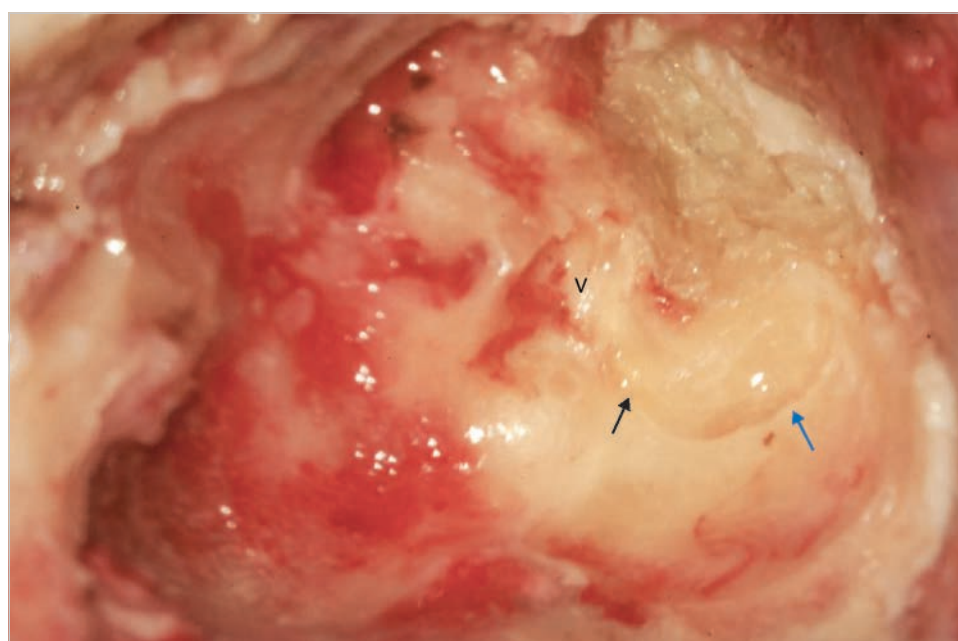


Fig. 14.656 The atrophic facial nerve is removed, and the lateral and the posterior semicircular canals are drilled. The vestibule is opened from lateral of the posterior wall is lowered, and the attic is opened. The common crus that connects the superior (*blue arrow*) and the posterior semicircular canals to the vestibule can be identified in the medial wall (*black arrow*). V, vestibule.

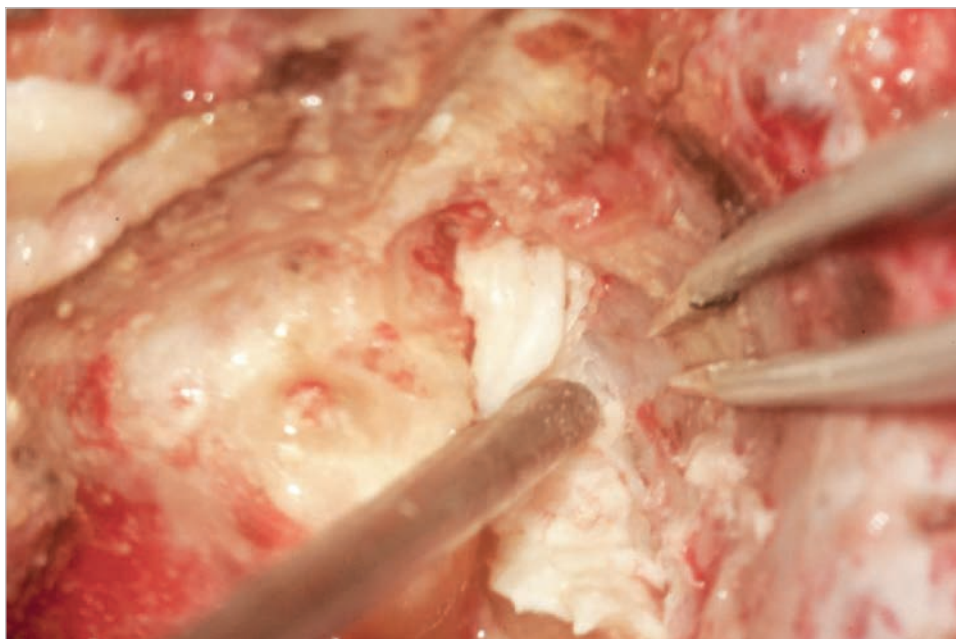


Fig. 14.657 The middle fossa dura is extensively covered by the very thin matrix of the cholesteatoma. The dura is coagulated with bipolar to reduce possibility to leave vital skin on it, and to make room for dissection by shrinking the dura.

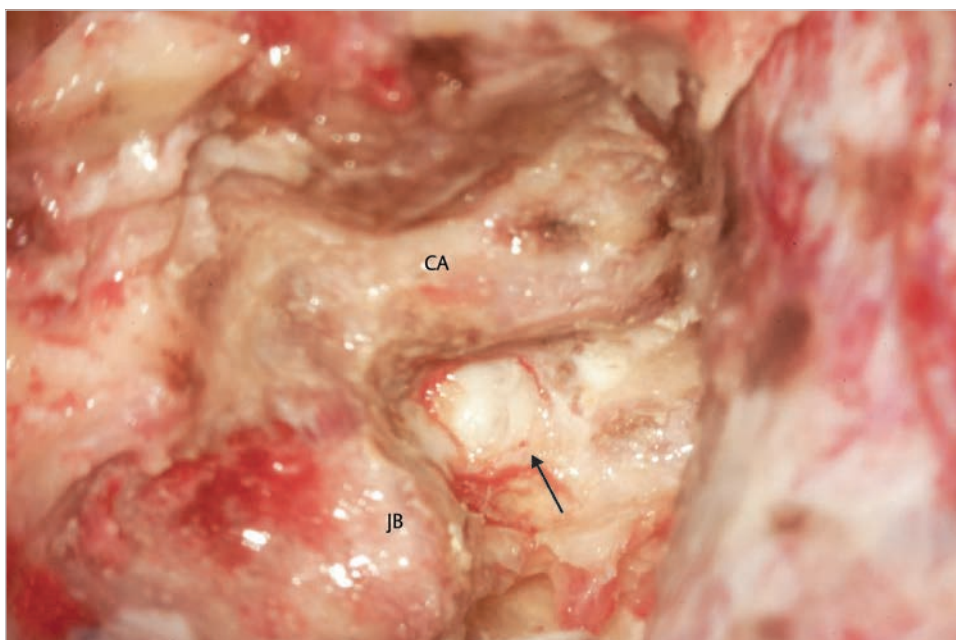


Fig. 14.658 The medial wall of the tympanic cavity including the cochlea is drilled and the carotid artery and the jugular bulb are skeletonized. Medially to the carotid artery, the cholesteatoma occupying the petrous apex is started to be seen (arrow). CA, carotid artery; JB, jugular bulb.

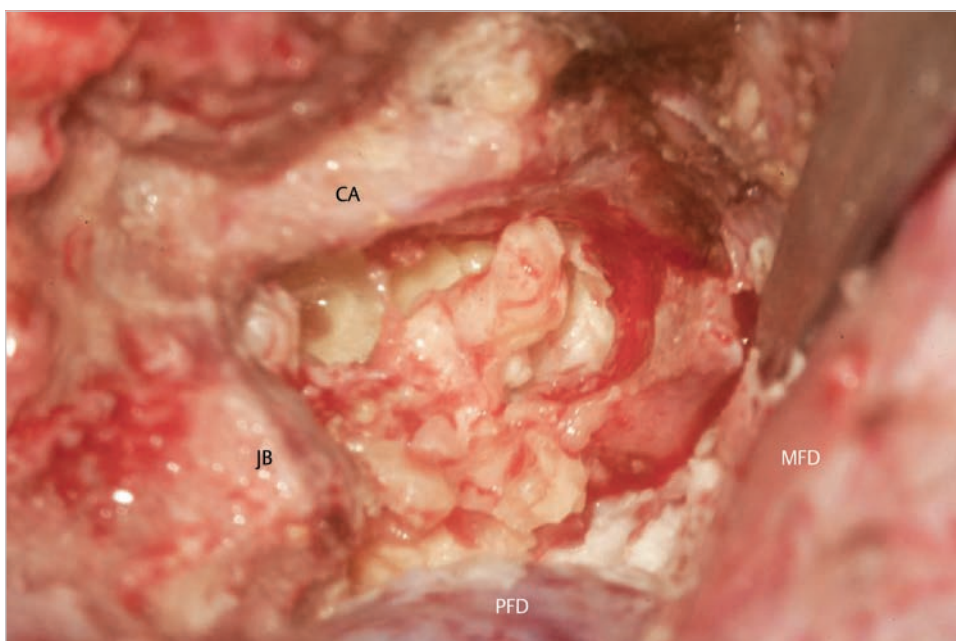


Fig. 14.659 Further drilling of the bone medially exposed massive cholesteatoma occupying the petrous apex. CA, carotid artery; JB, jugular bulb; MFD, middle fossa dura; PFD, posterior fossa dura.

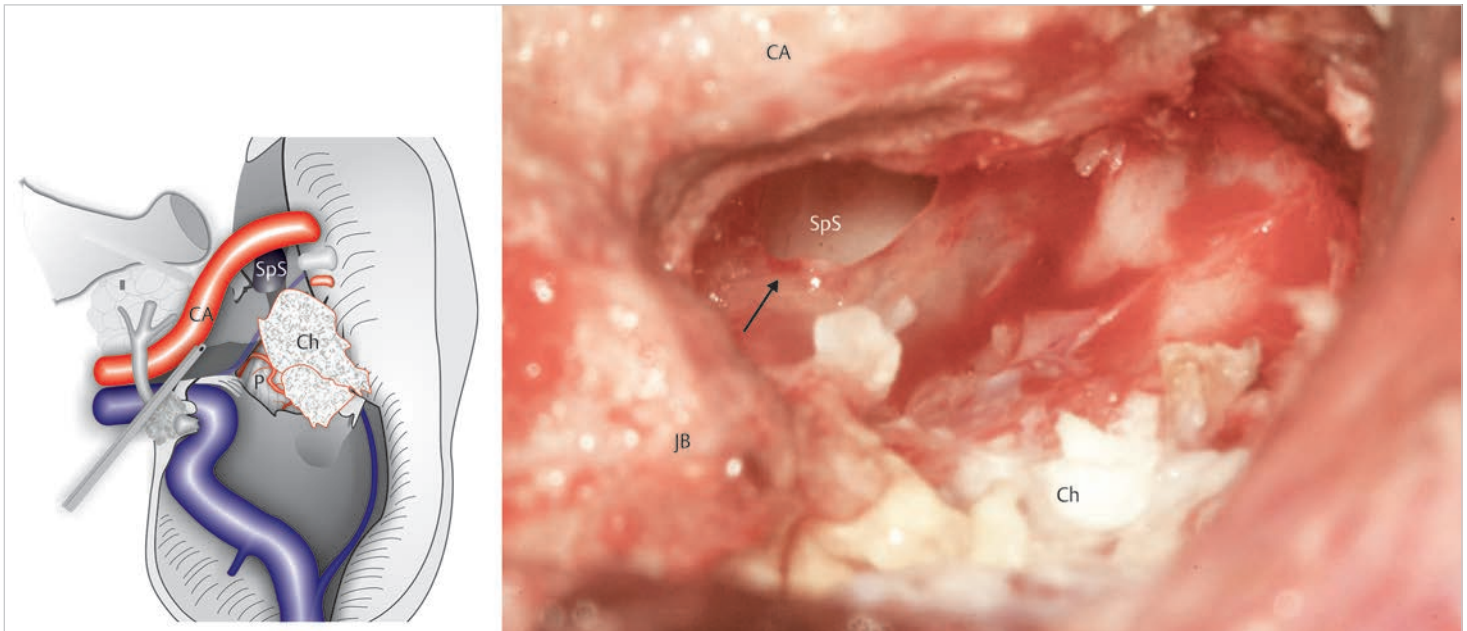


Fig. 14.660 An opening of sphenoid sinus is seen in the petroclival area medially to the carotid artery (*arrow*). The mucosa in the sphenoid is preserved and pushed medially, and the sinus is obliterated with a piece of muscle. CA, carotid artery; Ch, cholesteatoma; JB, jugular bulb; SpS, sphenoid sinus.

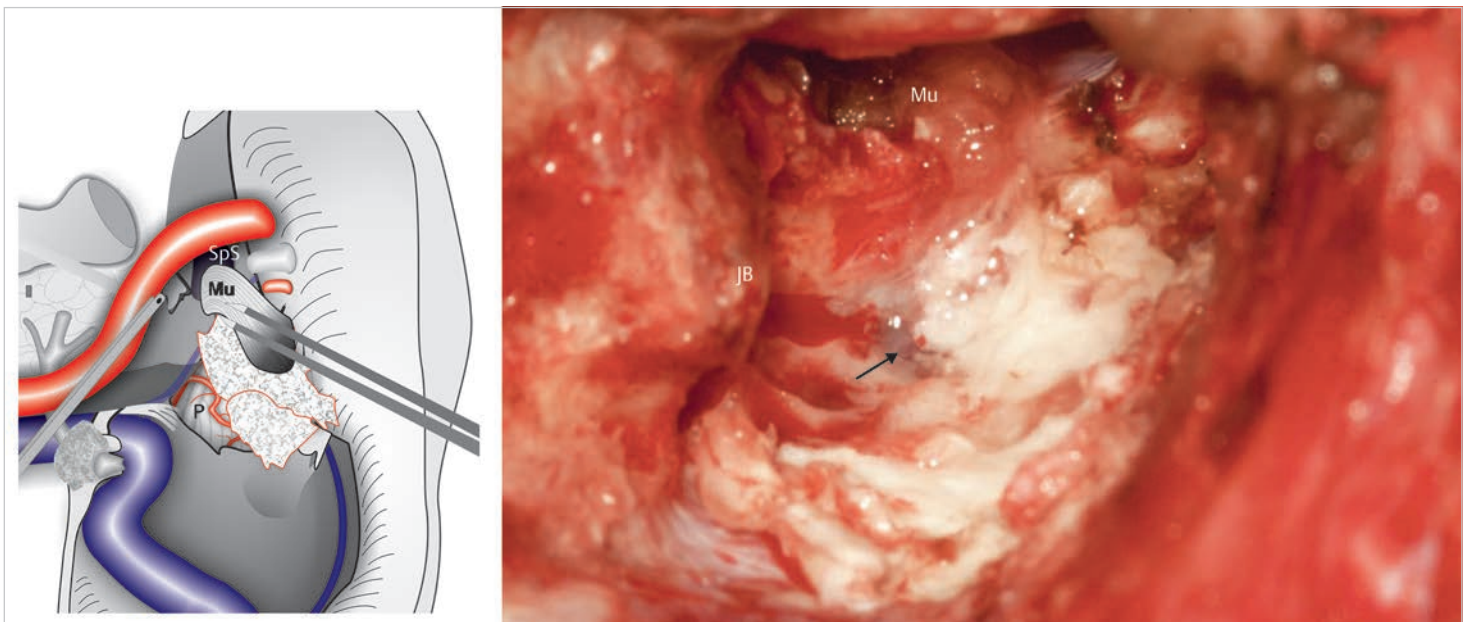


Fig. 14.661 A piece of muscle used to pack the sphenoid sinus is seen. The area of the internal auditory canal (*arrow*) is still covered with thick debris of cholesteatoma. JB, jugular bulb; Mu, muscle in the sphenoid sinus; SpS, sphenoid sinus.

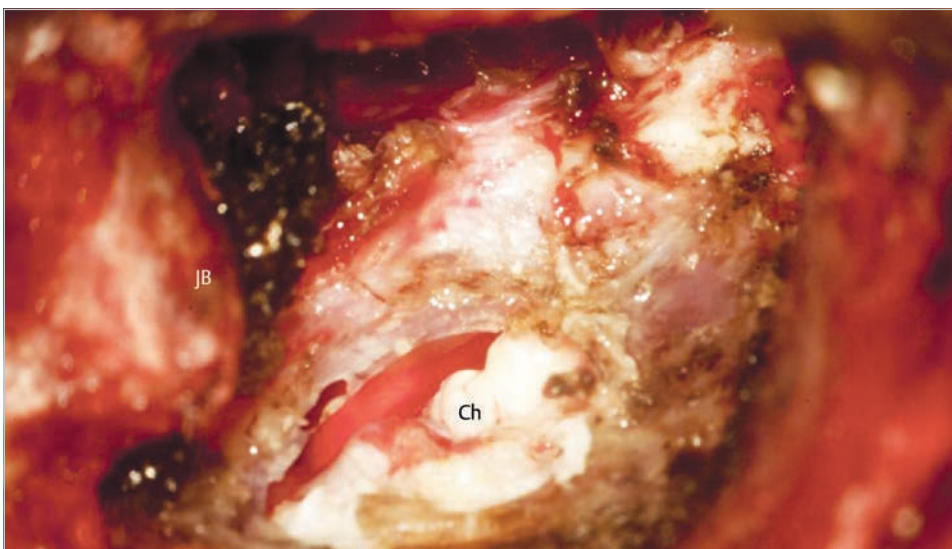


Fig. 14.662 Removal of the debris covering the posterior fossa dura exposed the other opening at the area of the internal auditory canal. From this opening, the cholesteatoma extending to the cerebellopontine angle is seen. Ch, cholesteatoma; JB, jugular bulb.



Fig. 14.663 The opening of the dura is enlarged to control the cerebellopontine angle better. The sixth cranial nerve (N. abducens; *black arrow*) running obliquely from bulbopontine angle to the upper clivus is seen. The nerve has close relationships with the anterosuperior cerebellar artery (AICA; *yellow arrow*). Management of intracranial space requires different kind of skill and anatomical knowledge from those of middle ear surgery. To manage intracranial lesion, the surgeon should be prepared for such situations.

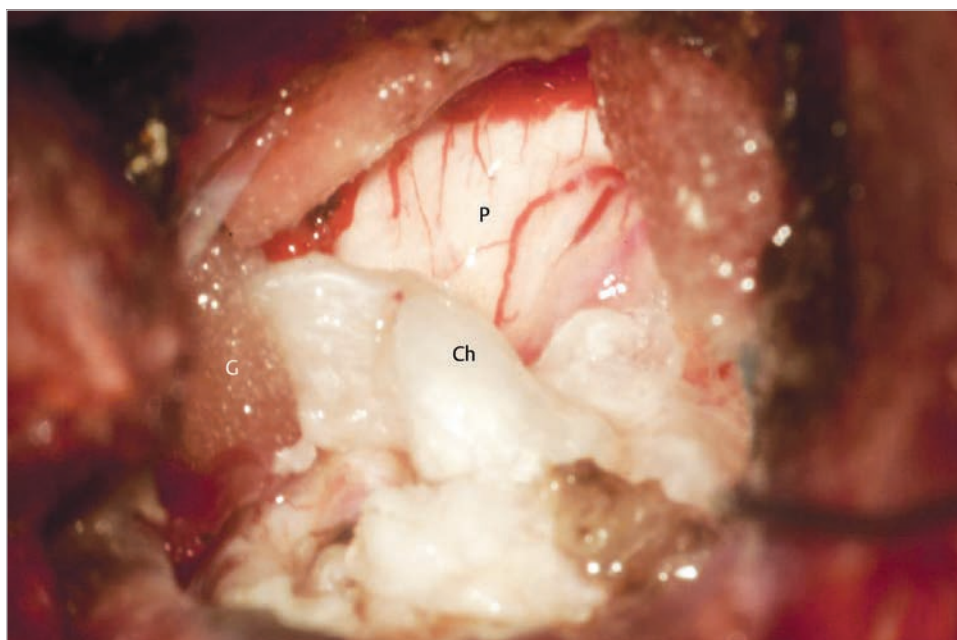


Fig. 14.664 The cholesteatoma attached to the pons is shown. Ch, cholesteatoma; G, Gelfoam; P, pons.

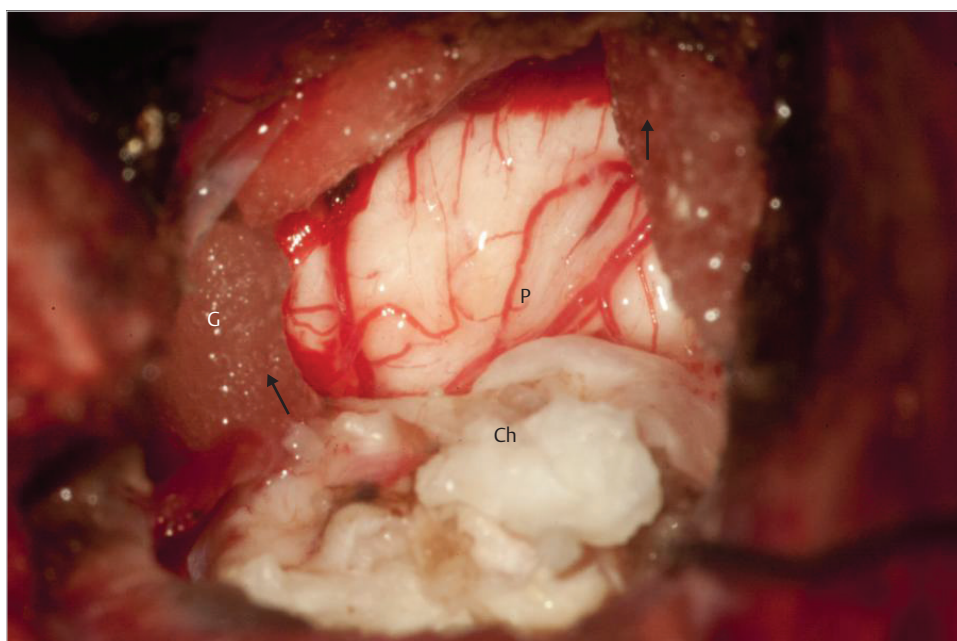


Fig. 14.665 The cholesteatoma is reduced, and the matrix is dissected carefully from the pons. Meticulous care should be taken in the cerebellopontine angle not to disrupt and coagulate major vessels, especially AICA and perforating arteries on the pons. Lethal complication may follow. Ch, cholesteatoma; G, Gelfoam; P, pons.

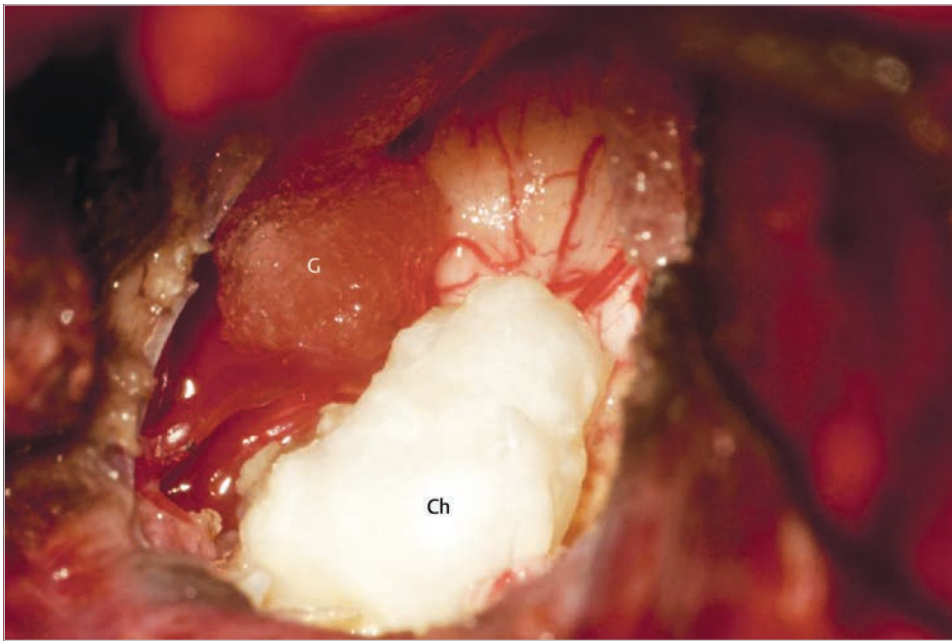


Fig. 14.666 The cholesteatoma is further dissected and reduced from the cerebellopontine angle taking care not to leave matrix behind. Ch, cholesteatoma; G, Gelfoam.

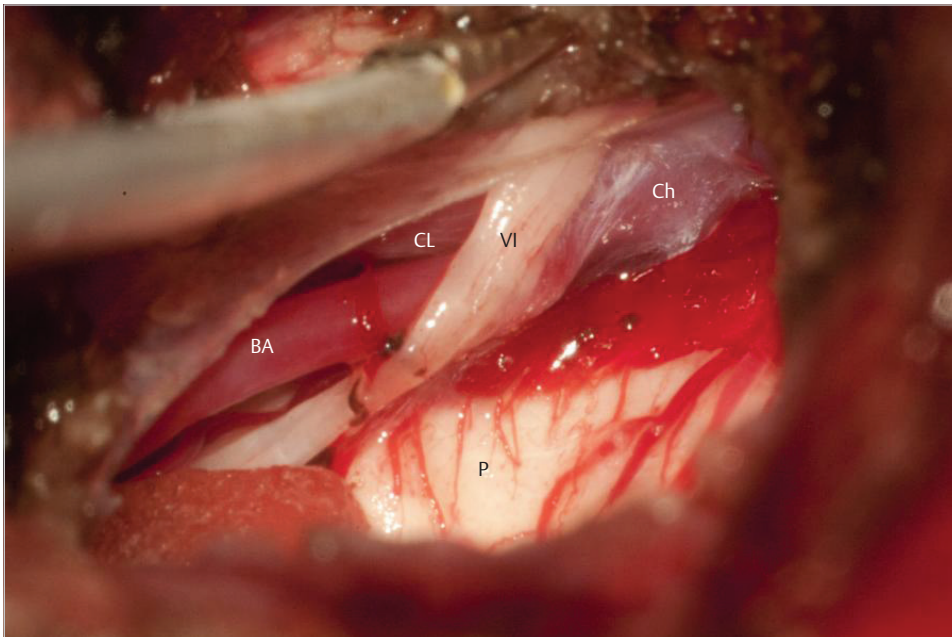


Fig. 14.667 The majority of cholesteatoma is removed from the cerebellopontine angle, except a piece of matrix superomedially to the sixth cranial nerve. BA, basilar artery; Ch, cholesteatoma; CL, clivus; P, pons; VI, N. abducens.

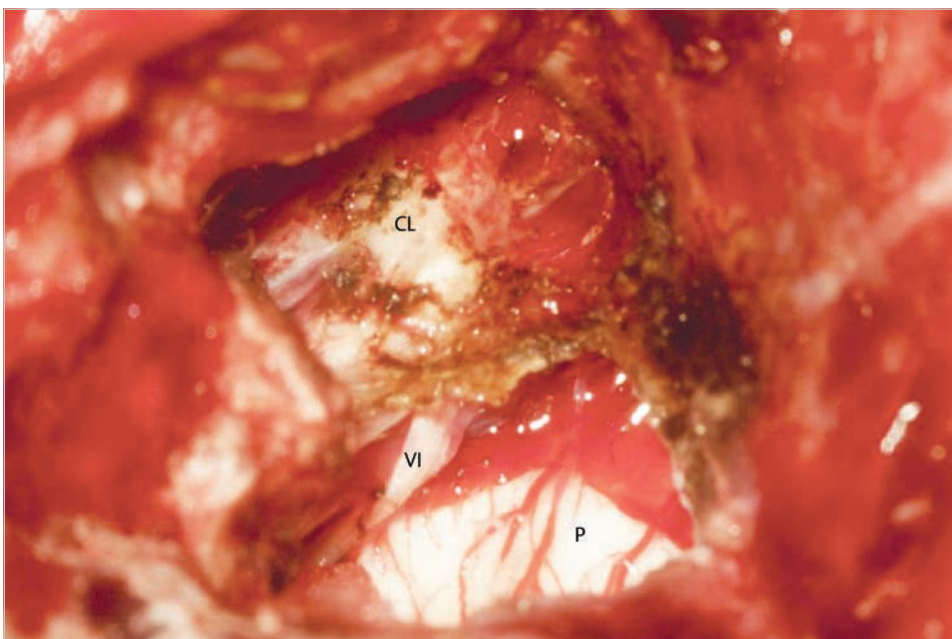


Fig. 14.668 The remnant of the cholesteatoma superiorly to the sixth cranial nerve is removed. CL, clivus; P, pons; VI, N. abducens.

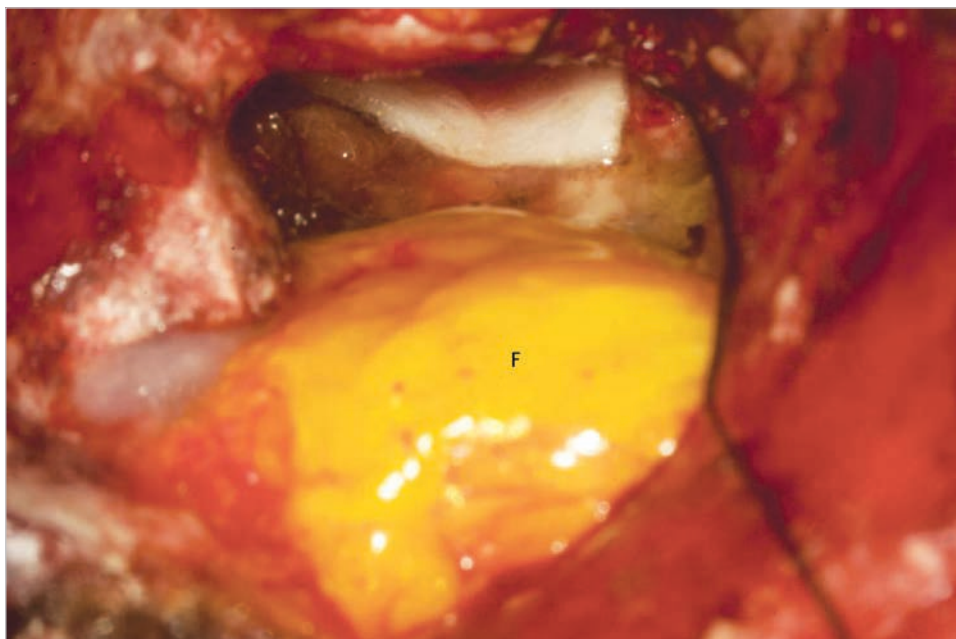


Fig. 14.669 The opening of the dura is closed with a small piece of abdominal fat. The cavity is further obliterated with abdominal fat. The cavity is further packed with the same material. F, abdominal fat.

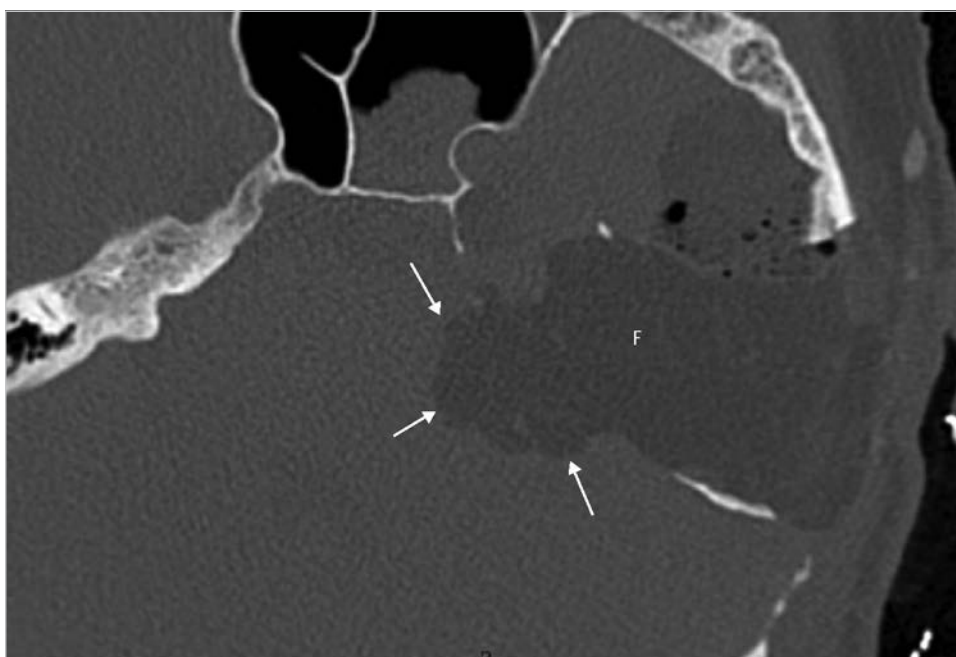


Fig. 14.670 The postoperative CT immediately after the surgery shows extensive removal of the temporal bone. Note that the abdominal fat is pushed into the cerebellopontine angle (*arrows*) to tightly seal opening of the dura to avoid CSF leak. F, abdominal fat.

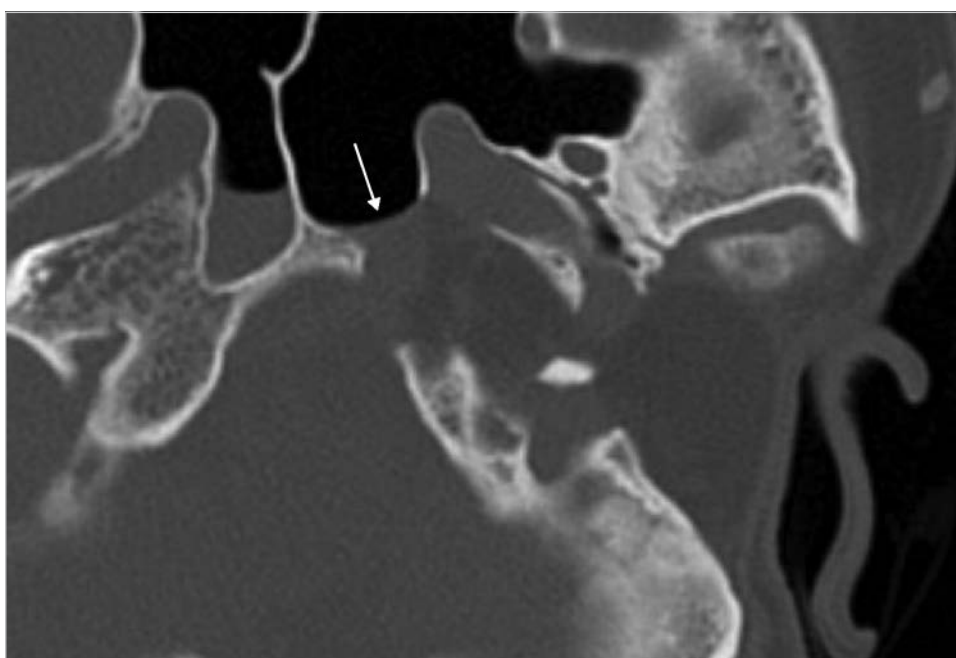


Fig. 14.671 Postoperative CT 4 years after the surgery shows complete closure of the opening in the petrous apex to the sphenoid sinus (*arrow*).

Case 14.29 (Right Ear)

See ▶ Fig. 14.672, ▶ Fig. 14.673, ▶ Fig. 14.674, ▶ Fig. 14.675, ▶ Fig. 14.676, ▶ Fig. 14.677, ▶ Fig. 14.678, ▶ Fig. 14.679, ▶ Fig. 14.680, ▶ Fig. 14.681, ▶ Fig. 14.682, ▶ Fig. 14.683, ▶ Fig. 14.685, ▶ Fig. 14.686, ▶ Fig. 14.687, ▶ Fig. 14.688, ▶ Fig. 14.689, ▶ Fig. 14.690, ▶ Fig. 14.691, ▶ Fig. 14.692, ▶ Fig. 14.693, ▶ Fig. 14.694, ▶ Fig. 14.695, ▶ Fig. 14.696, ▶ Fig. 14.697, ▶ Fig. 14.698.

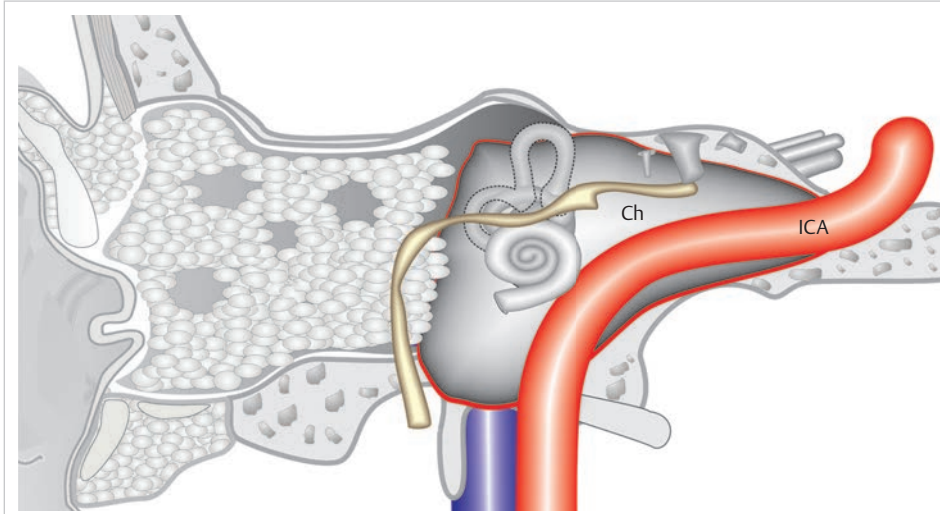


Fig. 14.672 A case of massive petrous bone cholesteatoma after preperformed translabyrinthine approach in other center removed with modified transcochlear approach combined with infratemporal fossa approach type B.

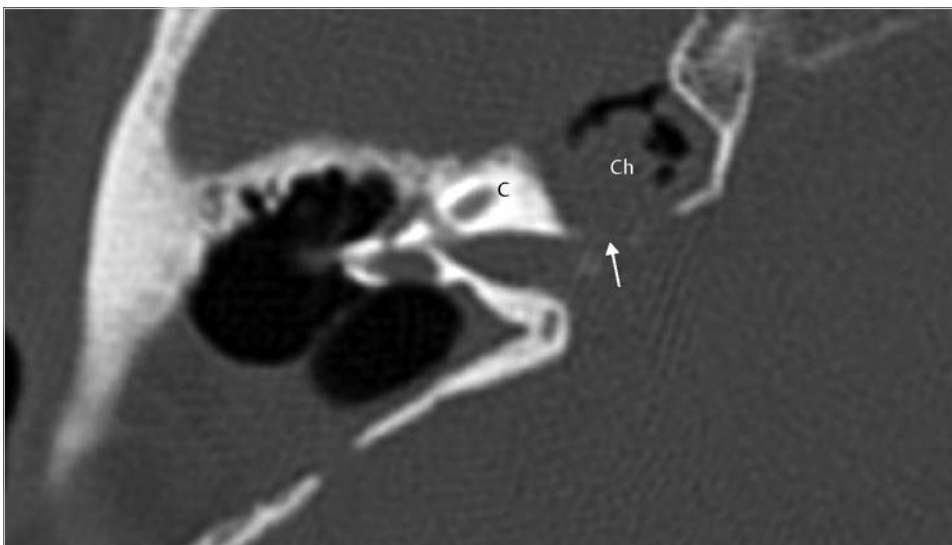


Fig. 14.673 The patient underwent surgery elsewhere 6 years before visiting our office. The external auditory canal has been closed, and the cavity is filled with abdominal fat. A dead ear with facial weakness resulted. The axial CT at the level of the labyrinthine segment of the facial nerve shows recurrence of cholesteatoma in the petrous apex to erode the internal auditory canal (arrow). C, cochlea; Ch, cholesteatoma.

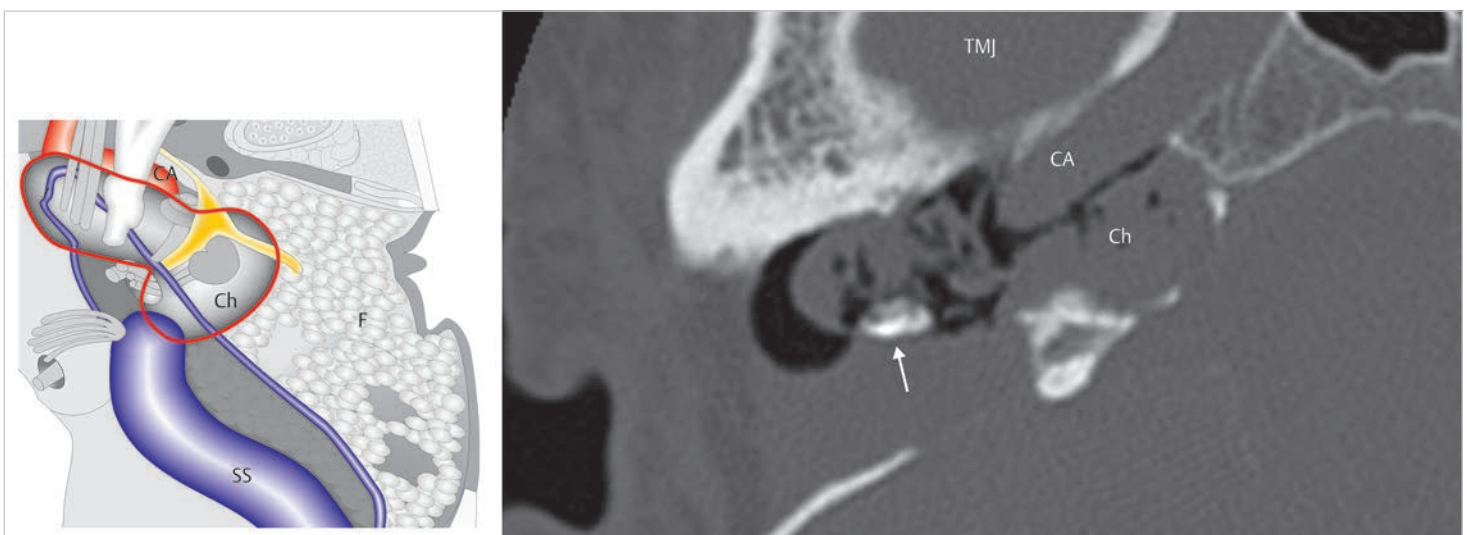


Fig. 14.674 The posterior face of the horizontal portion of the internal carotid artery is extensively exposed in the cavity and covered with the cholesteatoma. The skeletonized facial nerve (arrow) is surrounded by the cholesteatoma. F, abdominal fat; CA, carotid artery; Ch, cholesteatoma; S, sphenoid; SS, sigmoid sinus; TMJ, temporomandibular joint.

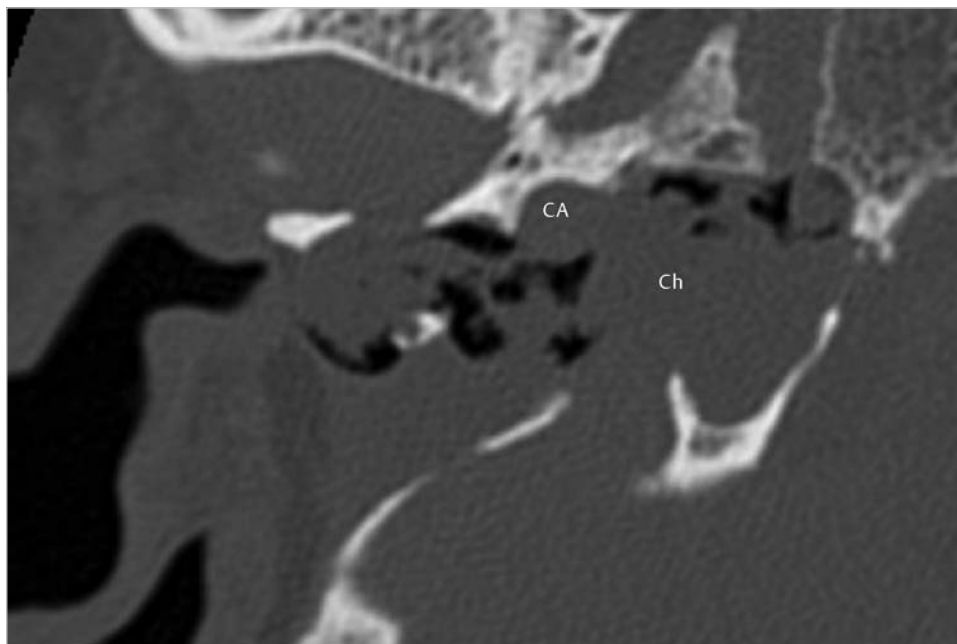


Fig. 14.675 More caudal section of the CT scan is shown. The cholesteatoma (Ch) totally occupying the petrous apex, exposing the jugular bulb (JB) and the vertical segment of the carotid artery is shown. The arrow indicates skeletonized facial nerve. CA, carotid artery; Ch, cholesteatoma.

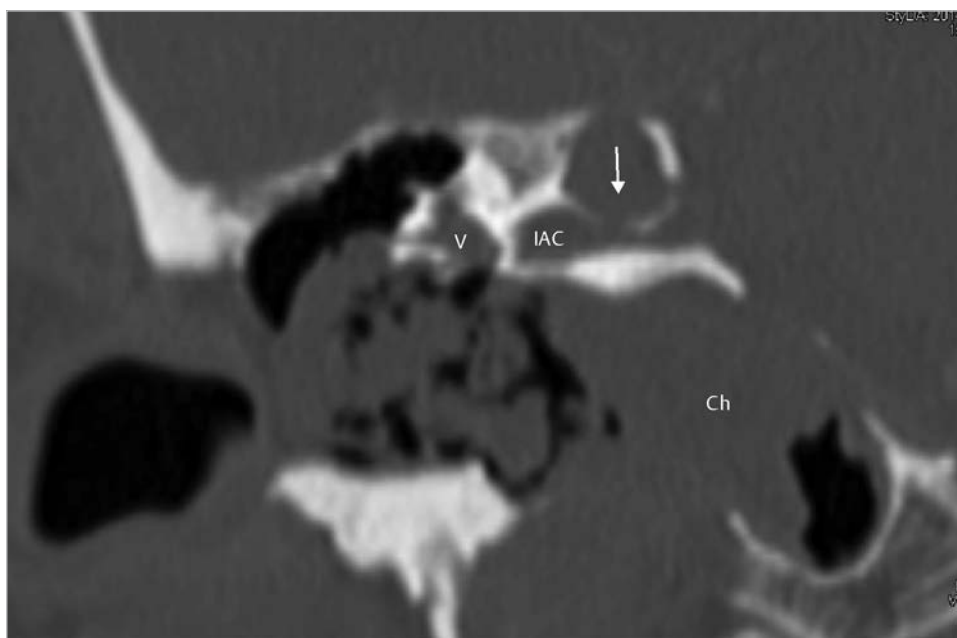


Fig. 14.676 The coronal section of CT scan shows cholesteatoma (Ch) reaching the area of the clivus. The internal auditory canal is eroded (*arrow*), and a small remnant of the posterior labyrinth located just lateral to the fundus is seen. Note prominent residual of the bone covering the middle fossa that limits access to the deep area. Ch, cholesteatoma; IAC, internal auditory canal; V, vestibule.

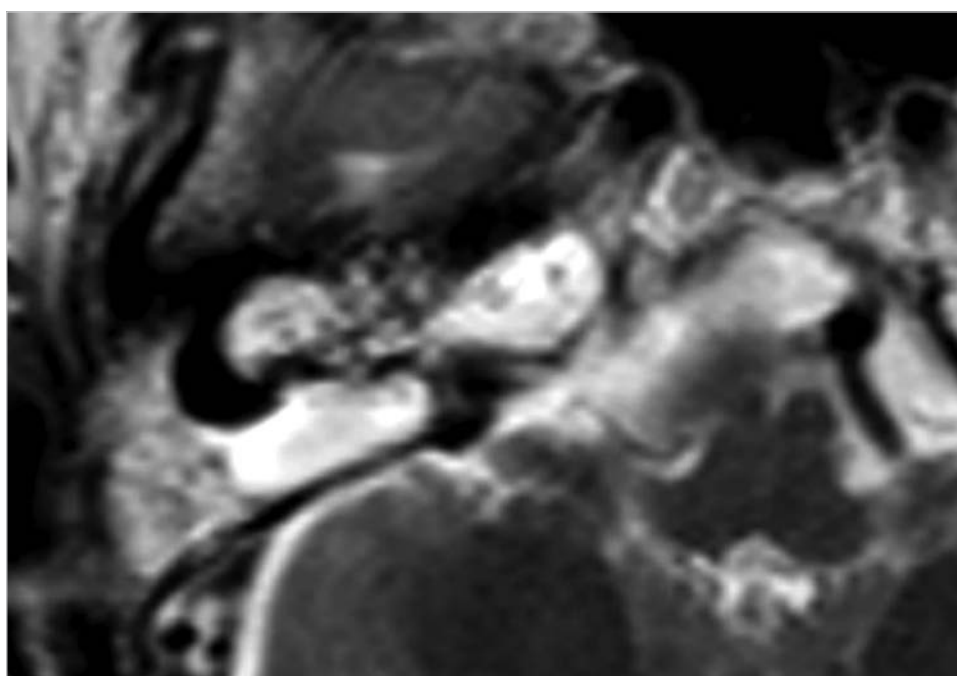


Fig. 14.677 In T2-weighted image of MRI, extensive cholesteatoma filling the petrous bone is identified as a high-signal area.

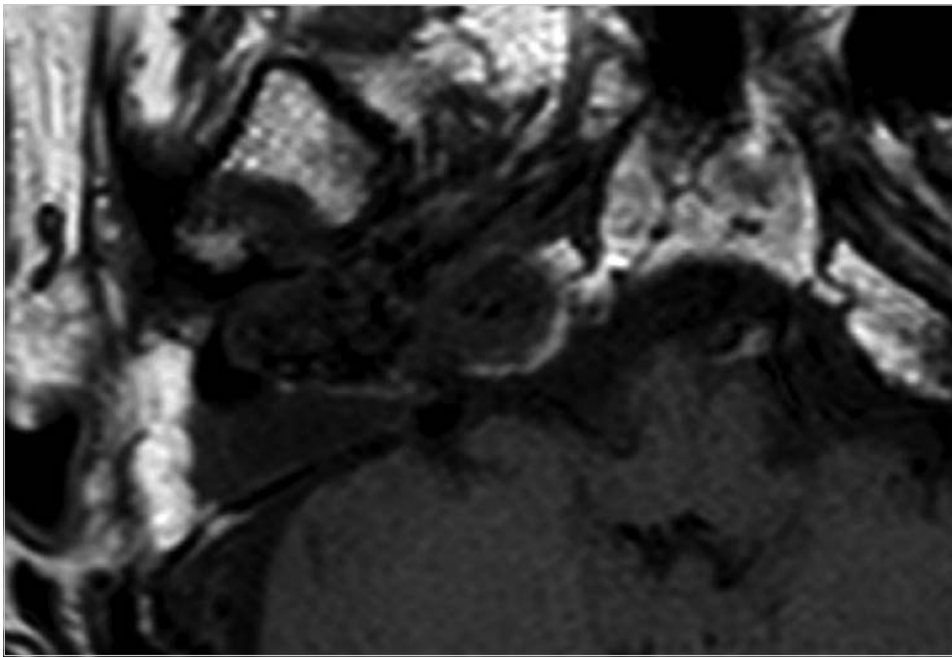


Fig. 14.678 In T1-weighted image, the area shows low signal intensity. Identification of each structure inside the temporal bone is not possible.

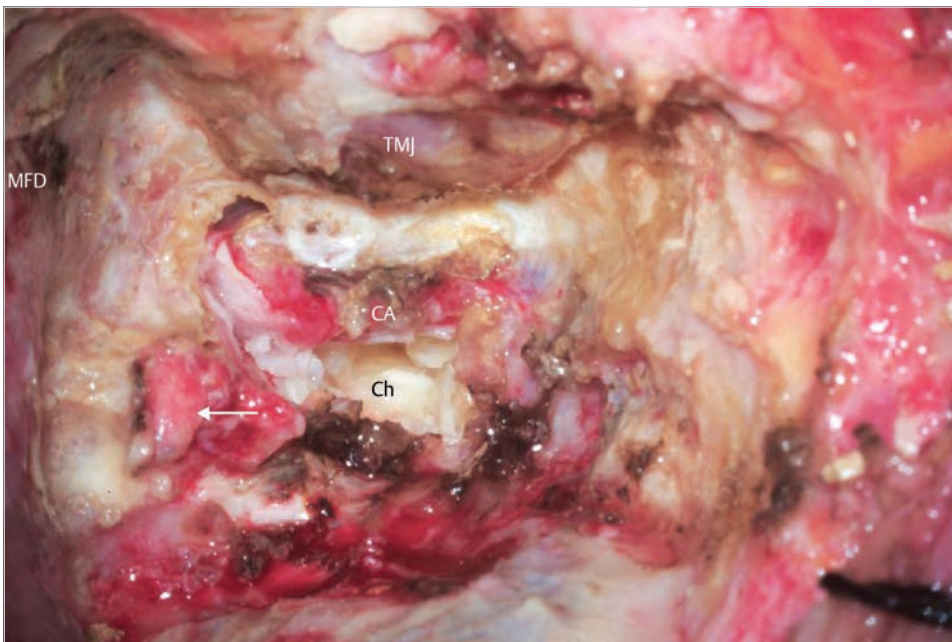


Fig. 14.679 Because of long-standing facial nerve weakness, presence of cholesteatoma (Ch) in very deep area, and very thin bony coverage over the entire course of the facial nerve, sacrifice of the facial nerve is decided. The arrow indicates the proximal stump of the nerve. To control huge cavity and the carotid artery the dura is uncovered, and the temporomandibular joint is exposed. The carotid artery exposed in the cavity is started to be seen. CA, carotid artery; Ch, cholesteatoma; MFD, middle fossa dura; TMJ, temporomandibular joint.

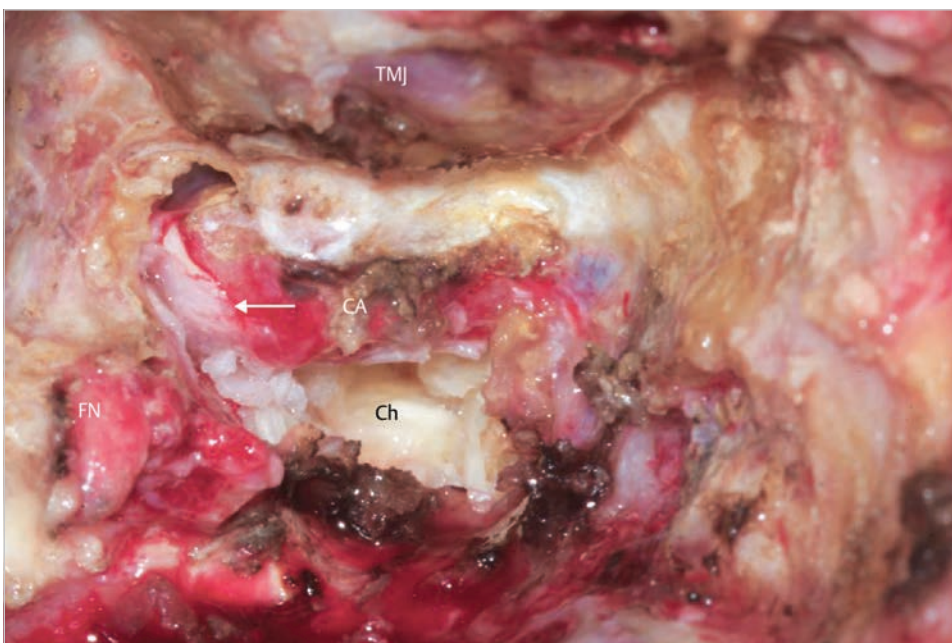


Fig. 14.680 Closer look. The cholesteatoma goes far medially, and the carotid artery is covered with matrix (arrow). CA, carotid artery, vertical portion; Ch, cholesteatoma; FN, proximal stump of facial nerve; TMJ, temporomandibular joint.

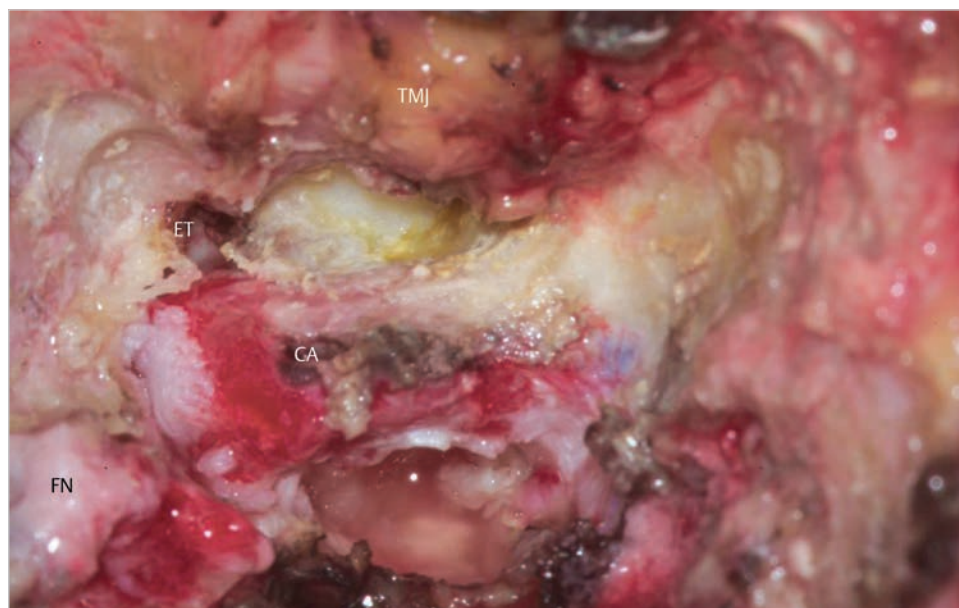


Fig. 14.681 To control better the area of the clivus, the carotid artery should be mobilized. The carotid artery is started to be exposed by removing the bone posteriorly, inferiorly, and anteriorly. CA, carotid artery; ET, eustachian tube; FN, facial nerve; TMJ, temporomandibular joint.

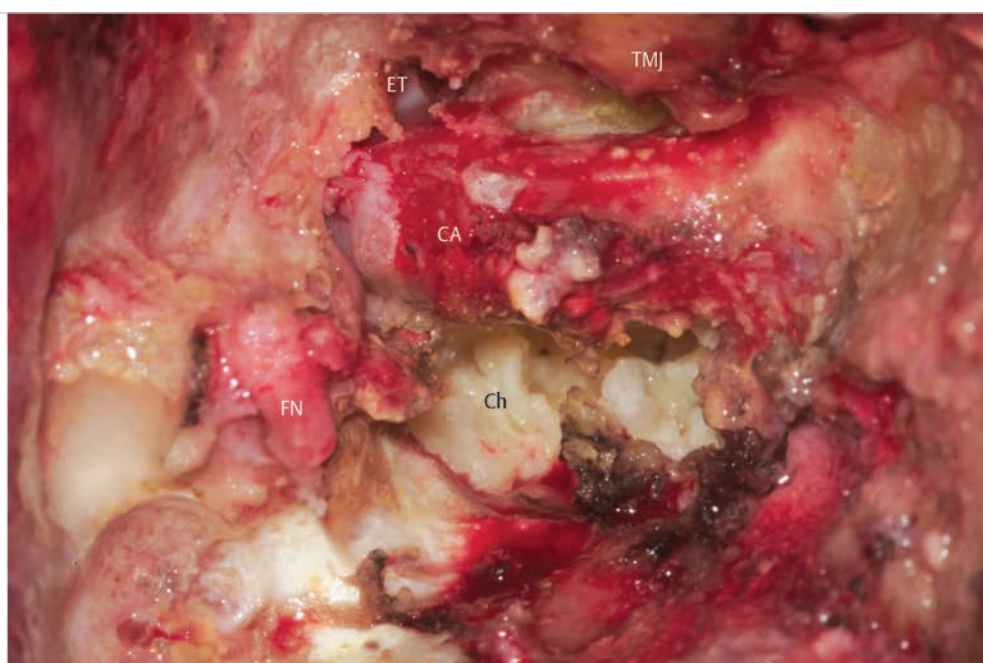
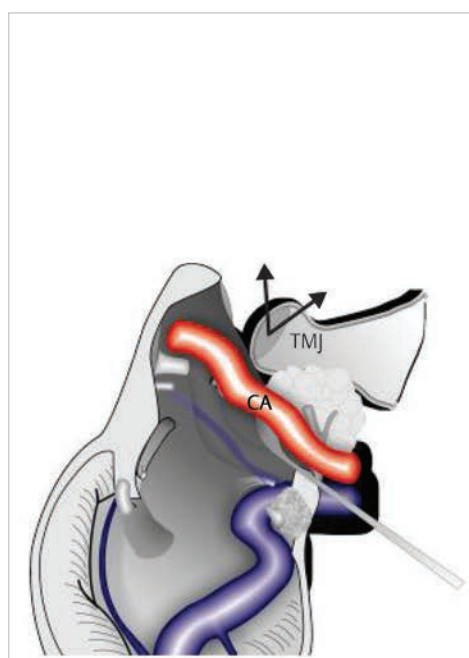


Fig. 14.682 To control the anterior face of the carotid artery, the temporomandibular joint is pushed anteroinferiorly with a self-retaining retractor. CA, carotid artery; Ch, cholesteatoma; ET, eustachian tube; FN, facial nerve; TMJ, temporomandibular joint.

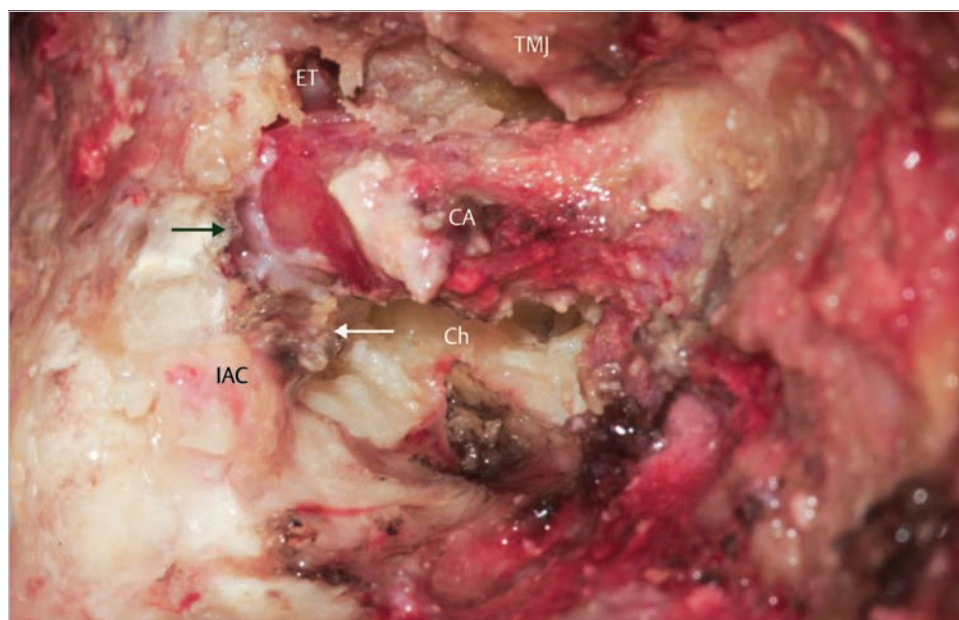


Fig. 14.683 The remnant of cochlea located just posteriorly to the carotid artery is drilled to expose the lateral end of the internal auditory canal. The nerves in the internal auditory canal is coagulated at the fundus (*white arrow*). Note the matrix covering the posterosuperior face of the horizontal portion of the carotid artery (*black arrow*). CA, carotid artery; Ch, cholesteatoma; ET, eustachian tube; IAC, internal auditory canal; TMJ, temporomandibular joint.

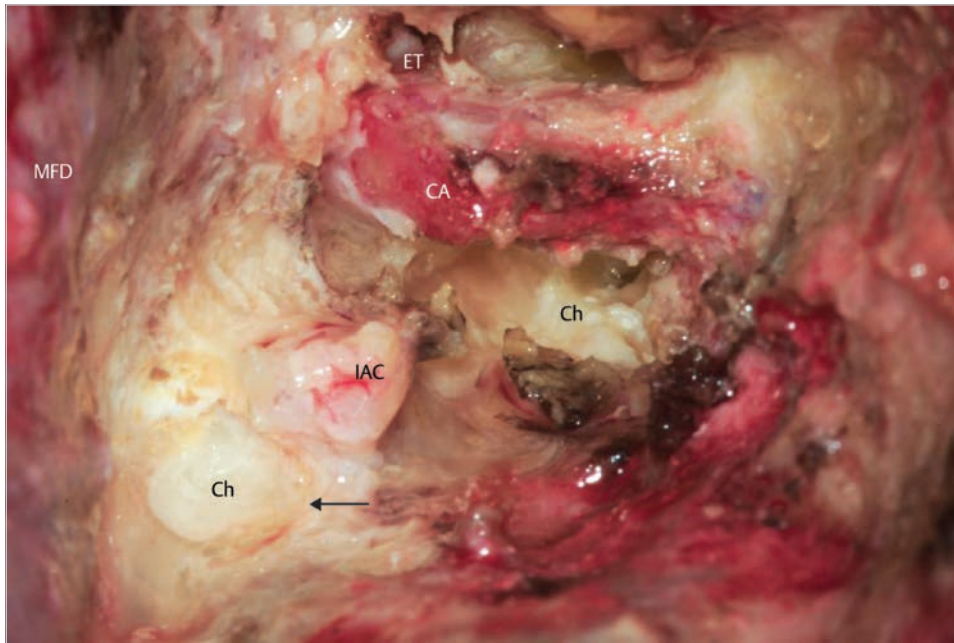


Fig. 14.684 The bone covering the lateral part of the internal auditory canal is removed to expose cholesteatoma infiltrating the space between the middle fossa dura and the internal auditory canal (*arrow*). CA, carotid artery; Ch, cholesteatoma; ET, eustachian tube; IAC, internal auditory canal; MFD, middle fossa dura.



Fig. 14.685 The bone between the horizontal segment of the carotid artery and the posterior fossa dura, located anteriorly to the internal auditory canal is removed to open the superior part of the petrous apex. The content of the internal auditory canal is depressed by the suction irrigator. CA, carotid artery; MFD, middle fossa dura.



Fig. 14.686 The superior part of the petrous apex is started to be opened. The middle fossa plate is further thinned with large diamond burrs taking care not to damage the carotid artery. CA, carotid artery; IAC, internal auditory canal; MFD, middle fossa dura.

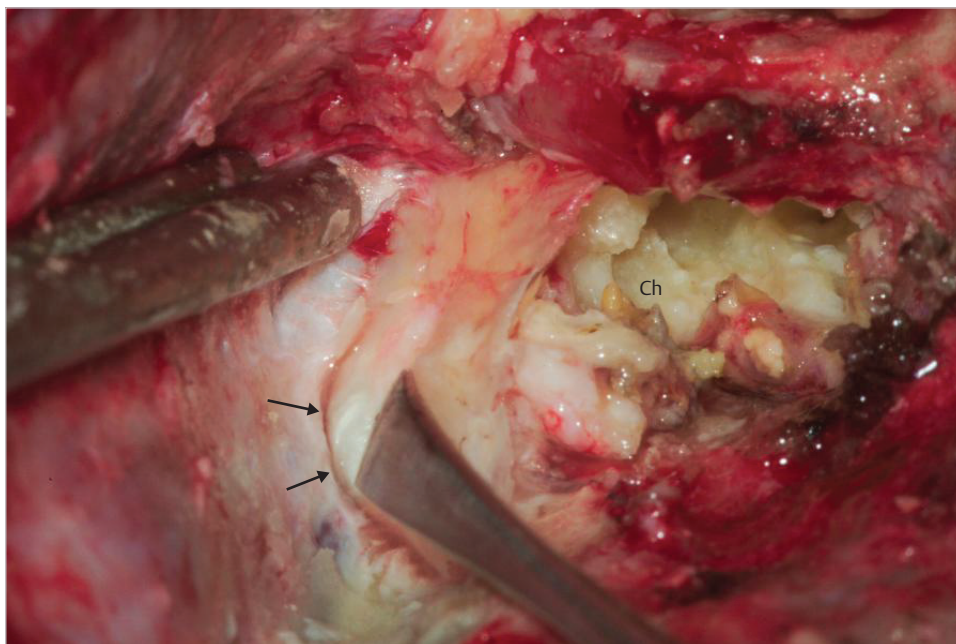


Fig. 14.687 The thinned bone covering the middle fossa dura located superiorly and medially to the internal auditory canal is detached from the dura with a large raspatorium. The superior pole of the cholesteatoma between the internal auditory canal and the middle fossa dura is exposed (*arrows*). Ch, cholesteatoma.

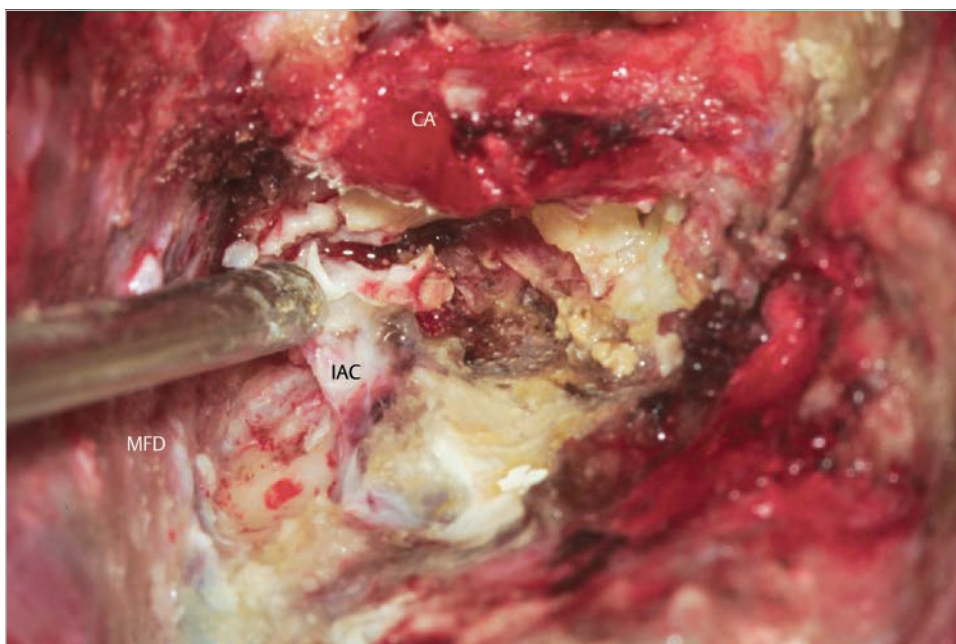


Fig. 14.688 Dissection of the cholesteatoma from the middle fossa dura and the posterior fossa plate is advanced medially. To ensure complete removal of the cholesteatoma from the internal auditory canal, the dura of the internal auditory canal is coagulated and removed with its contents, taking care not to damage the anteroinferior cerebellar artery that may get into the internal auditory canal. CA, carotid artery; IAC, internal auditory canal; MFD, middle fossa dura.

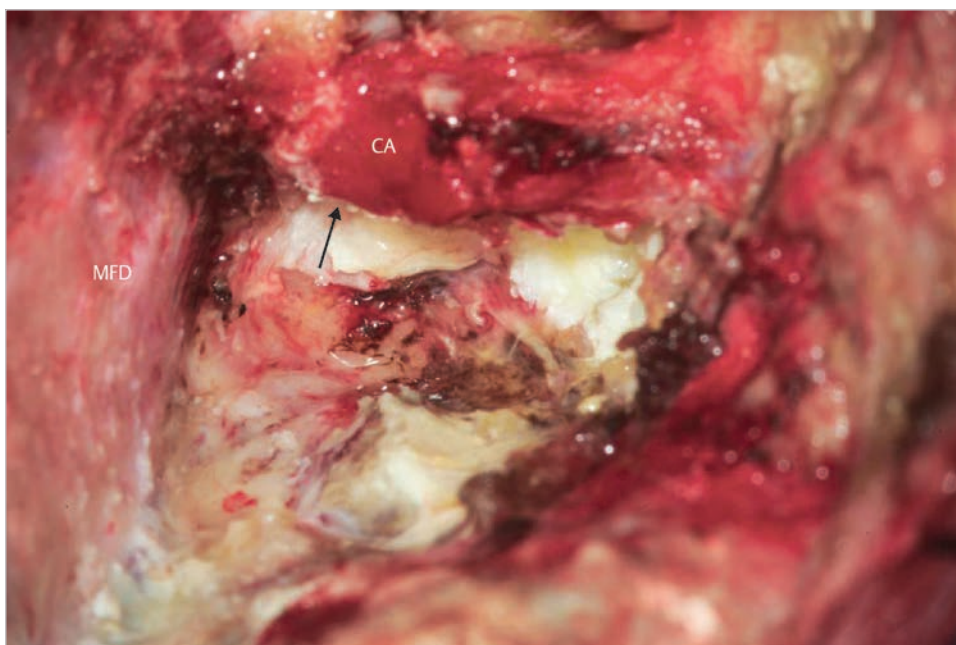


Fig. 14.689 The most anterosuperior part of the cholesteatoma lodging medially to the carotid artery is seen. Note that the posterior face of the carotid artery is still covered with the cholesteatoma matrix (*arrow*), but the area is hard to see directly if the carotid artery is in place. CA, carotid artery; MFD, middle fossa dura.

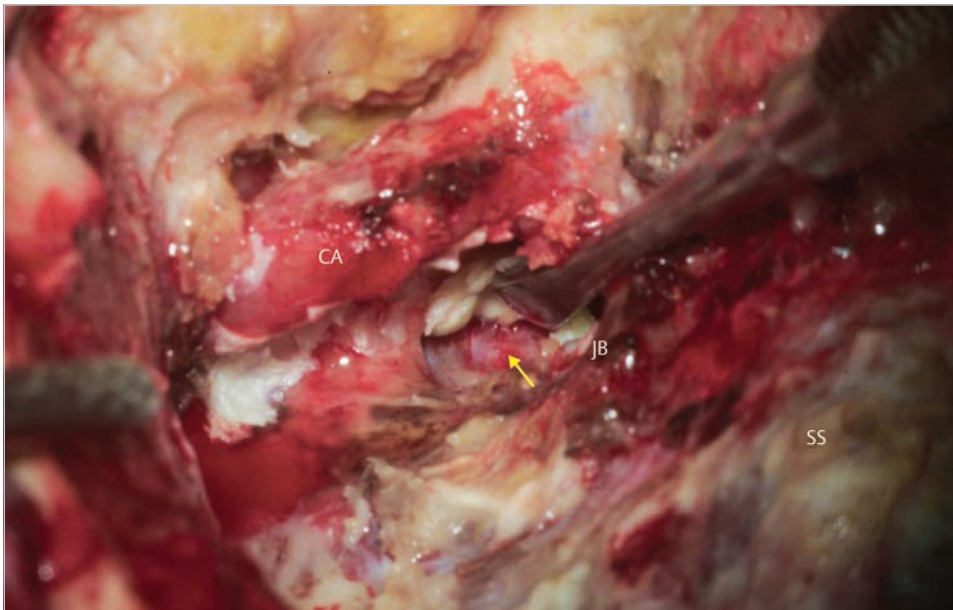


Fig. 14.690 The most anteroinferior part of cholesteatoma lodging deeply in the clivus located anteriorly to the jugular bulb (arrow) is dissected from the posterior fossa dura. CA, carotid artery; JB, jugular bulb; SS, sigmoid sinus.

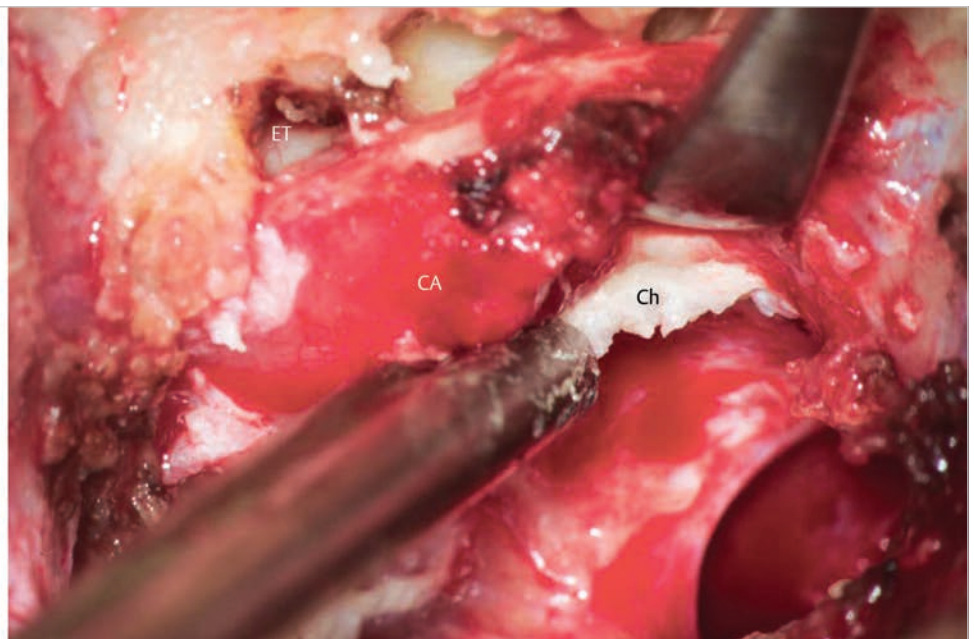
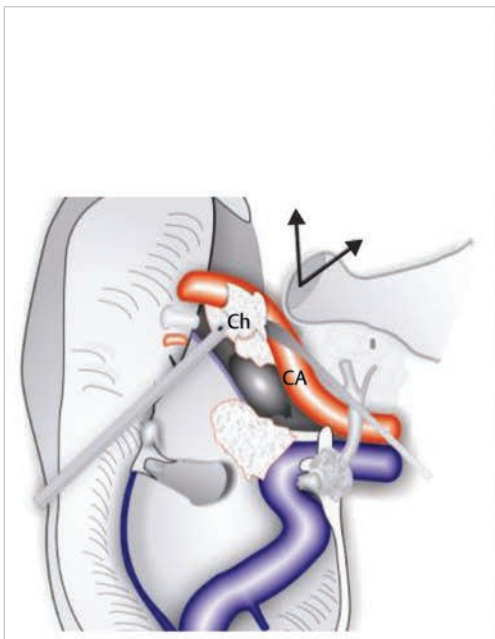


Fig. 14.691 Mobilization of the carotid artery gives much better visualization of the area located medially to the artery, and the area of the clivus. CA, carotid artery; Ch, cholesteatoma; ET, eustachian tube.

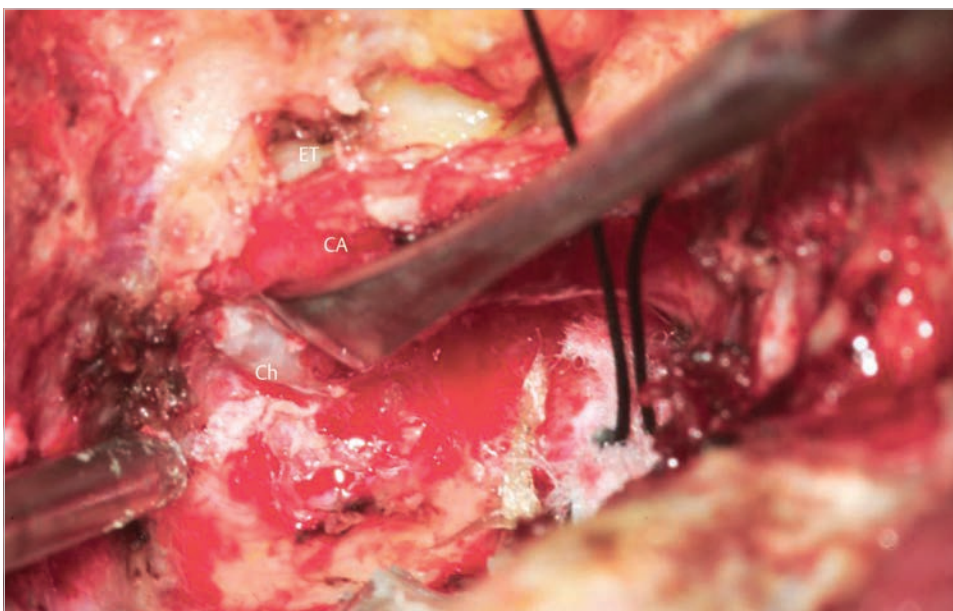


Fig. 14.692 The final part of cholesteatoma covering the posterior face of the horizontal portion of the carotid artery is dissected with a raspatory. CA, carotid artery; Ch, cholesteatoma; ET, eustachian tube.



Fig. 14.693 The clival bone infiltrated by cholesteatoma is drilled. CA, carotid artery; CL, clivus; ET, eustachian tube; SS, sigmoid sinus.

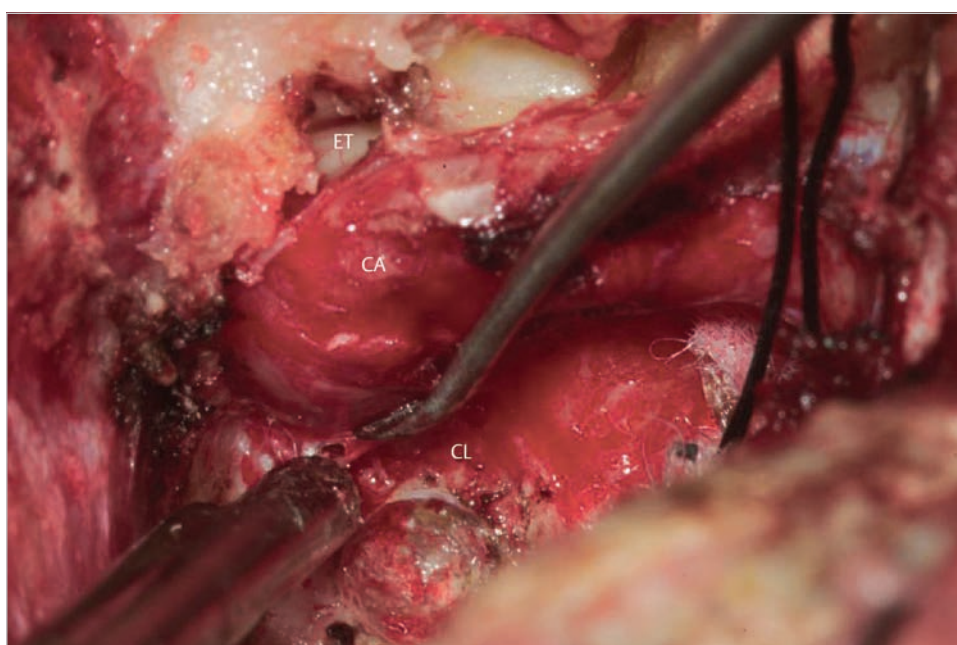


Fig. 14.694 The final piece of cholesteatoma covering the carotid artery is dissected using a microdissector. CA, carotid artery; CL, clivus; ET, eustachian tube.

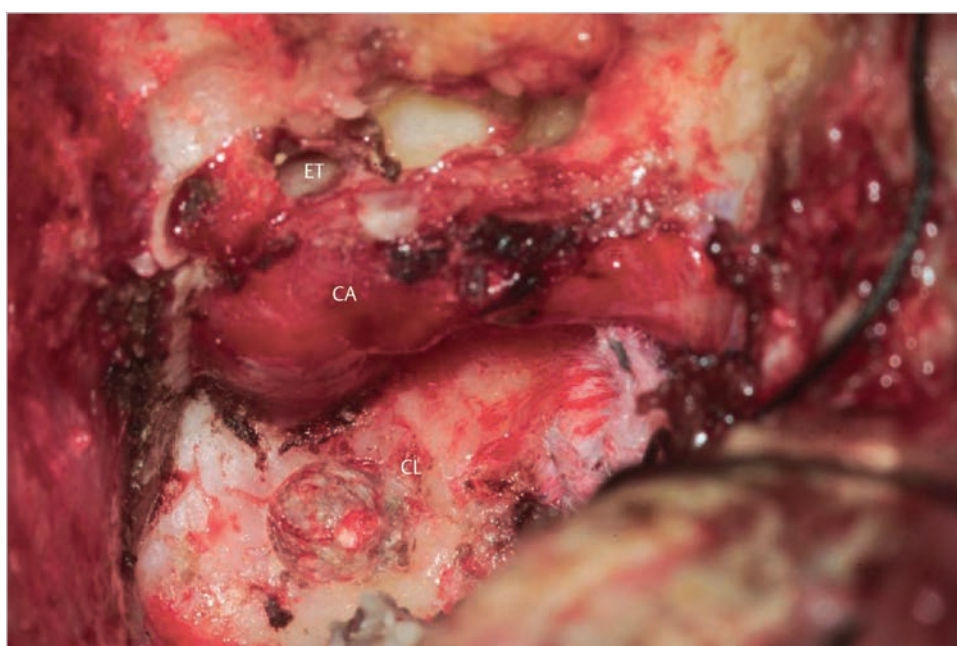


Fig. 14.695 Removal of the cholesteatoma is accomplished. To introduce strong motor neurons that reactivate the facial nerve suffering weakness for long period, the hypoglossofacial anastomosis is chosen for restoration of the facial nerve function. CA, carotid artery; CL, clivus; ET, eustachian tube.

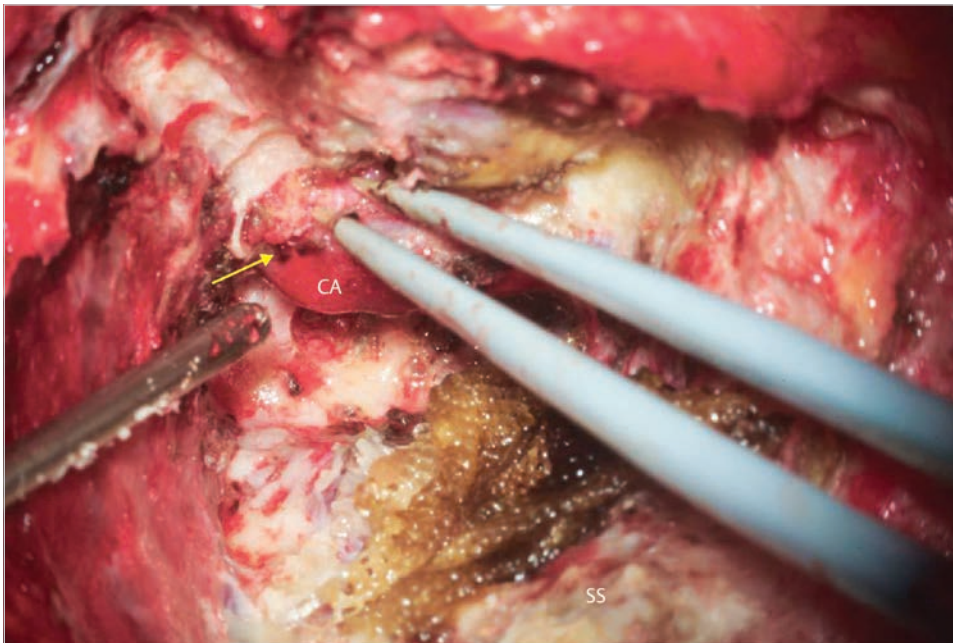


Fig. 14.696 The eustachian tube is packed with pieces of periosteum (*arrow*), and the cavity is packed with abdominal fat. CA, carotid artery; SS, sigmoid sinus.

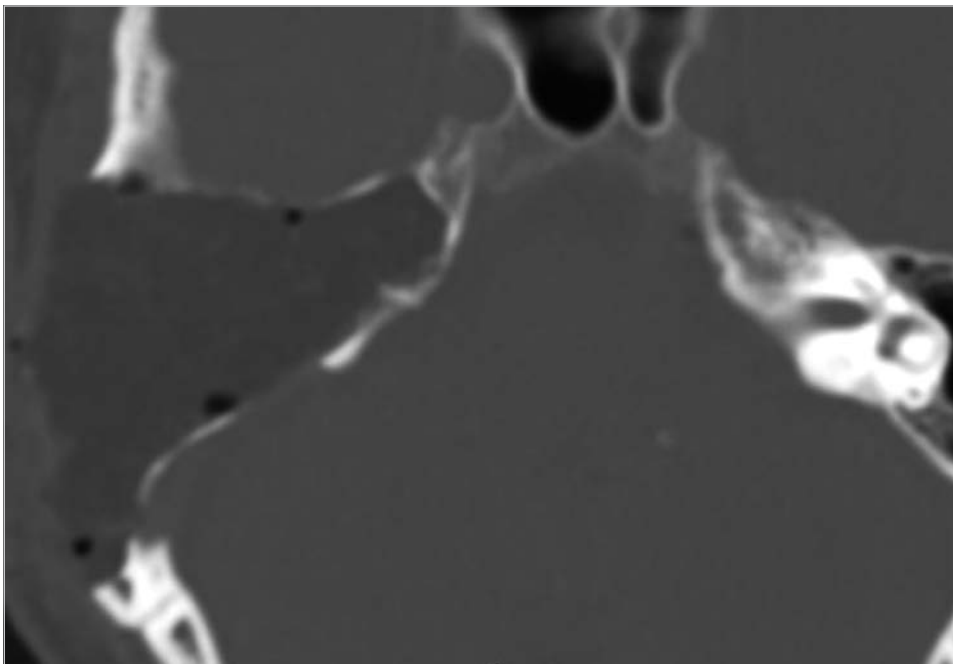


Fig. 14.697 Postoperative CT shows complete removal of the inner ear.

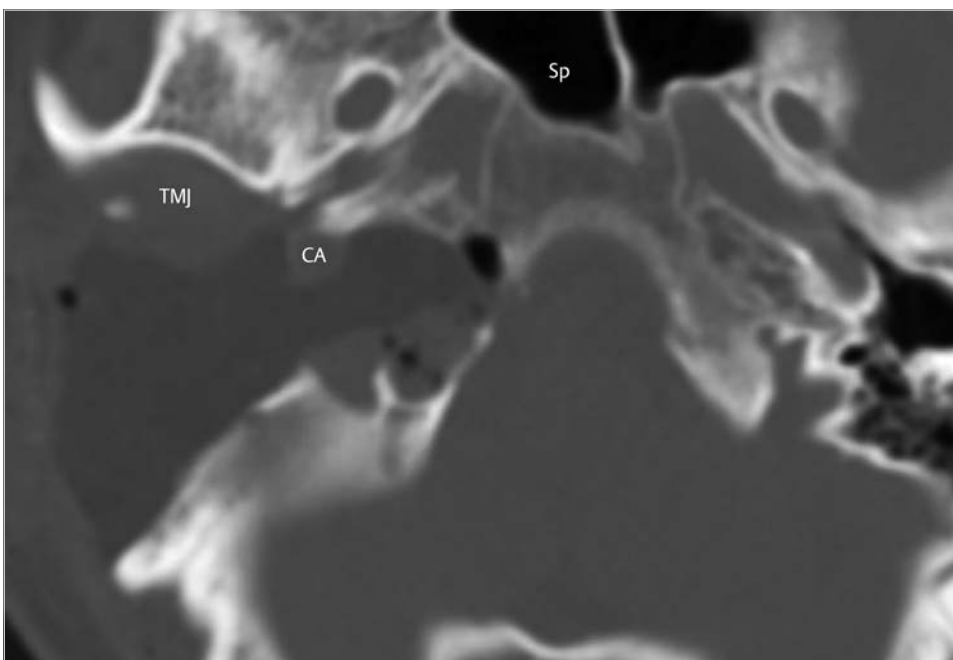


Fig. 14.698 The vertical segment of the carotid artery is totally uncovered, and the capsule of the temporal joint is exposed. CA, carotid artery; SpS, sphenoid sinus; TMJ, temporomandibular joint.

14.8 Hints and Pitfalls in the Management of Petrous Bone Cholesteatoma

14.8.1 Hints

1. A correct diagnosis can be achieved only by following a standard classification. Applying a management algorithm also depends on firstly classifying the tumor.
2. During the planning of the surgery, radical resection of the lesion takes precedence to hearing preservation. In most cases of PBCs, hearing preservation becomes impossible.
3. If the cochlea can be preserved, a cochlear implant can be used if it is the only hearing ear or as a sleeper implant in older patients.
4. If the facial nerve is normal preoperatively, all attempts must be made to preserve the nerve. It is rarely necessary to reroute the facial nerve. If the facial nerve is sacrificed or damaged accidentally, it must always be reconstructed using a cable interpositioning of a nerve graft.
5. Never open the dura if the lesion is not intradural. An opening runs the risk of meningitis or seeding of the lesion.
6. When the lesion is close to or involves the jugular bulb, always assess the contralateral venous drainage using angio-MRI, as it may be necessary to close the sigmoid–internal jugular vein complex if there is a puncture of the bulb while removing the lesion.
7. PBCs almost never infiltrate the petrous internal carotid artery. The matrix can be gently separated from the artery. If certain parts of the matrix is adherent, they can be coagulated. However, in many cases, the lesion encases the vertical segment of the carotid, going medial and even anterior to it. In more extensive cases, it may be in relation to the inferior to the horizontal portion of the carotid. Exposing the carotid by drilling out the tympanic bone is vital in such cases. The entire vertical portion, genu, and even the horizontal position can be isolated by drilling the bone around it. The carotid can then be transposed using an arterial tape to access areas of the petrous bone medial to the carotid.
8. A 10-year follow-up is recommended for all patients undergoing surgery for PBCs.

14.8.2 Pitfalls

1. Approaching a lesion without classifying it leads to unexpected situations during surgery.
2. Insufficient knowledge of the neuroradiology of this area leads to dangerous situations during surgery. It is always recommended to take the opinion of an expert neuroradiologist before performing surgery on this disease.
3. Hearing preservation surgeries have almost no role in PBCs. Even in limited PBCs, they are often very closely related to the cochlea and rarely can hearing be preserved.
4. An open cavity for such lesions is contraindicated. These cavities are very large and leads to constant cavity-related problems for the patient. It is always better to perform a blind-sac closure of the external auditory canal after filling the cavity with abdominal fat.
5. Never peel the matrix over the dura by force as this can lead to a defect and subsequent CSF leak. On the contrary, leaving behind matrix will lead to a certain recurrence. Hence the only way to tackle adherent matrix over the dura is to coagulate it with a bipolar using low-grade diathermy.
6. A matrix over the jugular bulb must be tackled very carefully. The bulb is very fragile, and the matrix must be peeled off carefully with neurosurgical patties. Minimal amount of matrix can be coagulated using a bipolar.
7. If the jugular bulb is accidentally punctured during dissection, it can be controlled by gentle coagulation using Surgicel. If there

is a large opening, the sigmoid sinus must be closed by packing it (extra- and intraluminally) with Surgicel proximal to the lesion. Distally the internal jugular vein must be quickly ligated in the neck. The lumen of the bulb can be packed with Surgicel.

8. The resection of a PBC usually leaves a large cavity. The cavity has to be obliterated adequately using abdominal fat. The eustachian tube must be closed tightly using periosteum, muscle, and bone wax.
9. Surgical approaches for large PBCs must be performed only after adequate training in skull base surgery. Adventurism is ill advised in such lesions. If one does not have adequate knowledge or experience in dealing with PBCs, it is better to refer such cases to an advanced center routinely performing such cases.
10. The biggest pitfall is to believe that this is a middle ear surgery and follow the cholesteatoma deeper. Dealing with PBCs is in the realm of skull base surgery.

Videos

See Video 14.1, Video 14.2.

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